28.1
43wa
ap.2

THE WATER WORKS SYSTEM

OF THE

CITY OF CHICAGO

REPORT PREPARED BY THE
CHICAGO BUREAU OF PUBLIC EFFICIENCY

DECEMBER, 1917

PRIOR PUBLICATIONS.

1. Method of Preparing and Administering the Budget of Cook County, Illinois. January, 1911.

2. Proposed Purchase of Voting Machines by the Board of Election Commissioners of the City of Chicago. May, 1911. (Out of Print.)

3. Street Pavement Laid in the City of Chicago: An Inquiry Into Paving Materials, Methods and Results. June, 1911. (Out of Print.)

4. Electrolysis of Water Pipes in the City of Chicago. July, 1911. (Out of Print.)

5. Administration of the Office of Recorder of Cook County, Illinois. September, 1911.

6. A Plea for Publi[illegible]er, 1911. (Out of Print.)

7. Rebuilding Asph[illegible]icago Under Contract of 1911.

8. The Municipal C[illegible]Which the Voters of Chicago W[illegible] of November 7—Vote No. Oc[illegible]

9. The Water Work[illegible]y H. Maury. December, 1911.

10. Bureau of Street[illegible]essment Accounting System o[illegible]of Print.)

11. Administration [illegible]linois. December, 1911.

12. Administration o[illegible] December, 1911.

13. Administration o[illegible]d of the Office of Clerk of the [illegible]mber, 1911.

14. The Judges [illegible]ut of Print.)

15. General Summa[illegible] Governments of Chicago. De[illegible]

16. The Park Gover[illegible]Organization and Methods of A[illegible]

17. Offices of the Cle[illegible]lemental Inquiry Into Their Co[illegible]ovember, 1912.

18. Administration o[illegible] of Cook County Illinois. Nov[illegible]

19. Office of Sheriff[illegible] Inquiry Into Its Organization[illegible]12.

20. Growing Cost of [illegible]mber 30, 1912.

21. The Voting Machine Contract. A Protest Against Its Recognition In Any Form by the City Council of the City of Chicago. January 1, 1913.

22. The Office of the County Treasurer of Cook County, Illinois. An Inquiry Into the Administration of its Finances with Special Reference to the Question of Interest on Public Funds. November, 1913.

23. The Nineteen Local Governments in Chicago. December, 1913.

24. The Bond Issues to Be Voted Upon April 7, 1914. March 30, 1914.

25. A Second Plea for Publicity in the Office of County Treasurer. July 9, 1914.

26. The Nineteen Local Governments in Chicago. (Second Edition.) March, 1915.

27. Unification of Local Governments in Chicago. January, 1917.

28. The City Manager Plan for Chicago. October, 1917.

29. The County Bond Issues to Be Voted Upon November 6, 1917. October 30, 1917.

30. Primary Days and Election Days as Holidays. An Instance of Governmental Absurdity and Waste. November 5, 1917.

31. Chicago's Financial Dilemma. Reply to a Letter from City Officials Asking Civic Organizations to Co-operate in Urging a Special Session of the Legislature to Provide Financial Relief for the City. December, 1917.

THE UNIVERSITY
OF ILLINOIS
LIBRARY
628.1
C43wa
Cop. 2
MUNICIPAL
REFERENCE

THE WATER WORKS SYSTEM

OF THE

CITY OF CHICAGO

REPORT PREPARED BY THE
CHICAGO BUREAU OF PUBLIC EFFICIENCY
315 PLYMOUTH COURT

CHICAGO BUREAU
OF
PUBLIC EFFICIENCY

TRUSTEES

JULIUS ROSENWALD, *Chairman*

ALFRED L. BAKER, *Treasurer*

ONWARD BATES
GEORGE G. TUNELL
WALTER L. FISHER
VICTOR ELTING
ALLEN B. POND
FRANK I. MOULTON

HARRIS S. KEELER, *Director*

628.1
C43wa
cop.2

AUG 2 CURRY

TABLE OF CONTENTS.

	Page
INTRODUCTION	9
SUMMARY AND CONCLUSIONS	13
The Water Works Plant	13
Water Works Finances	13
Water Fund Diverted to Corporate Uses	15
The Purity of the Water Supply	16
Water Waste and Leakage and Their Prevention	18
The Extent of Preventable Waste and Leakage	19
Effects of Waste and Leakage	20
Methods of Reducing Waste and Leakage	21
Metering	22
Meters Do Not Restrict the Use of Water	22
Meters Do Not Increase Water Bills	23
Universal Metering Recommended	24
The Saving to be Effected by Universal Metering	25
Responsibility for Existing Conditions	27
TEXT OF REPORT	31
I. General Description of the Plant	31
II. The Historical Development of the Water Works System	36
Pumping Stations	37
Chicago Avenue Station	37
Twenty-second Street Station	39
Harrison Street Station	41
Fourteenth Street Station	42
Further Extension of the City Limits in 1889	43
Lake View Station	43
Sixty-eighth Street Station	44
Territory Annexed Since 1889	46
Central Park Avenue and Springfield Avenue Stations	46
Roseland Station	48
Norwood Park, Edison Park, and Jefferson Park Stations	50
Rogers Park Station	50
Washington Heights Station	51
Morgan Park Station	51
Tunnels and Cribs	51
First Water Tunnel	51
Cross-Town and Blue Island Avenue Tunnels	51
North Shore Extension Tunnel	53
Four-Mile and Polk Street Tunnels	53
Lake View Tunnel	54

DEC 1 6 DIRECT

446504

Page

Sixty-eighth Street Tunnels 55
Northwest Land and Lake Tunnel 55
Southwest Land Tunnel 55
Description of an Intake Crib 56
Further Improvements Proposed or under Construction 57
Mayfair Station and Wilson Avenue Tunnel 58

III. Water Works Finances 59
The Value of the Water Works Plant 59
How the Cost of the Plant Has Been Financed 61
The Financial Status of the Water Works Business 64
Water Rates 65
Free Water 68
Revenue and Expenditures 70
Water Fund Diverted to Corporate Uses 80

IV. Chicago's Water Supply Problems 89
The Question of Cost 89
The Purity of the Supply 89
The Problem as Related to Health 89
Efforts to Avoid Pollution by Constructing Cribs and Tunnels 90
Efforts to Prevent Pollution by Diverting Sewage from the Lake 92
Present Condition of Lake Water at Chicago 94
Turbidity 102
The Need for Further Purification 103
Location of Intake Cribs as Related to Purity of Supply 104
Filtration 105
The Adequacy of the Supply 106
Chicago Pressures Insufficient 107
The Effect of Low Pressures 111
Fire Protection Service 111
Low Pressures Due to Excessive Friction Losses ... 112
Curtailment of Water Waste a Paramount Need .. 114

V. Water Waste and Leakage 115
"Use" and "Waste" Defined 115
Reducing Waste Does not Mean Restricting Use ... 116
The Waste Problem in Chicago 117
The Situation Prior to 1900 117
Developments Since 1900 118
Consumption of Water in Chicago Excessive 121
What Becomes of the Water Pumped in Chicago 124
Estimate of City Engineer 124
Consumption Classified According to Uses 124
Industrial Consumption 125
Domestic Consumption 125
Municipal Consumption 126

Page

Waste and Leakage 128
Water Lost in Delivery 128
Water Lost on Premises 129
Apparent Losses 129
Under-Registration of Meters 130
Preventable and Unpreventable Waste and Leakage ... 131
Pump Slippage 131
Leakage in the Distribution System 132
Waste and Leakage on Premises 134
The Extent of Preventable Waste and Leakage 136
Economic Loss Due to Waste 136
Waste Impairs Service 139
Effect of Waste on the Development and Cost of the Plant 139
Effect of Waste on Cost of Operation and Maintenance 144
Effect of Waste on the Cost of Filtration 146
Waste as Related to Sewage Disposal 147

VI. The Reduction of Water Waste 148
Reducing Losses in Delivery 149
Methods of Reducing Losses on Consumers' Premises . 152
House-to-House Inspections 153
Inspections Not Completely Effective 153
Inspection Method Costly 154
Inspections Produce Only Temporary Results 155
Penalties Must Be Enforced 156
Metering 157
Metering Effective, Permanent, and Economical ... 157
Metering the Equitable Way to Sell Water 158
Popular Objection to Metering 160
Meters Do Not Restrict "Use" of Water 161
Meters and Their Effect upon Water Bills 166
Universal Metering Recommended 174
Plans for Putting Universal Metering into Effect .. 175
Advantages of Plumbing Repairs Prior to Setting Meters 179
Metering Should Be Accompanied by Water Waste Surveys 179
Meters Should Be Installed and Maintained by City 180
Revenue Requirements and Water Rates 180
Minimum Charges 184
What Metering Will Effect: Waste Reduction—Improved Service—Money Saving 189
How Money Saving Will Be Effected 194
Savings in Capital Outlays for New Plant 196
Savings in Operating and Maintenance Costs 203
Total Saving to Be Effected 204
Responsibility for Existing Conditions 206

Tables: Page

Dimensions and Capacities of Chicago Water Tunnels .. 32
Chicago Pumping Stations—Number and Capacity of Pumps; Also Maximum and Average Daily Pumpage in 1916 34
Amount of Water Pipe in Use in Chicago at Close of 1916 36
Investment in Chicago Water Works Plant, 1902-1916 .. 60
How Cost of the Plant Has Been Financed 61
Financial Status of Chicago Water Works Business 64
Revenue of Water Fund, 1912-1916 71
Total Expenditures from Water Fund, 1912-1916 72
Revenue, Expenditures and Surplus of Water Fund, 1912-1916 73
Expenditures for Operation, 1912-1916 74
Expenditures for Repairs and Renewals, 1912-1916 75
Expenditures for Additions, Extensions, and Betterments, 1912-1916 76
Amounts Paid from Water Fund to General Corporate Fund 85, 86
Water Pressures at Various Points of the Distribution System for Certain Periods During 1917 109
Total Average Daily Consumption and Average Daily Consumption per Capita for Chicago, 1901-1916 121
Water Consumption Statistics of Various American Cities 123
Estimated Saving to Be Effected by Universal Metering, 1918-1950 .....27, 206

Maps:

Map Showing Pumping Stations, Tunnels, Cribs, and Territorial Growth of Chicago .....opposite 37
Map Showing Distribution of Population in Chicago ..... opposite 196

Charts:

Chart Showing Death Rate in Chicago from Typhoid Fever, 1875-1916 95
Chart Showing 1915 and 1916 Death Rates in Nine American Cities from Typhoid Fever 97
Chart Showing Rate of Increase of Population and of Average Daily Pumpage in Chicago, 1901-1916. 119
Chart Showing What Becomes of the Water Pumped in Chicago 127
Chart Showing Chicago's Preventable Water Waste Compared with the Combined Pumpage of Milwaukee, Boston, Cleveland, and St. Louis 135
Chart Showing Effect of Metering upon Pumpage in Cleveland 190
Chart Showing Effect of Metering upon Pumpage in Boston 192
Chart Showing Past and Estimated Future Growth in Population of Chicago 195

Charts (Continued): Page

Chart Showing Probable Future Effect of Complete Metering upon Daily Pumpage per Capita in Chicago 198

Chart Showing Probable Future Effect of Complete Metering upon Total Daily Pumpage in Chicago 199

Chart Showing Probable Effect of Complete Metering upon the Future Cost of Construction of the Chicago Water Works Plant 201

Chart Showing Estimated Saving to Be Effected by Universal Metering, 1918-1950 205

Illustrations:

Illustration Showing Size of Reservoir that Would Be Required to Hold One Day's Pumpage of the Chicago Water Works 29

Map of the United States Showing Distance Water Mains in Use in Chicago Would Extend if Placed End to End 30

Typical Profile Showing How the Water of Lake Michigan Flows from an Intake Crib to a Pumping Station 33

Photograph of Chicago Avenue Pumping Station 38

Photograph of Twenty-second Street Pumping Station 40

Photograph of Harrison Street Pumping Station 41

Photograph of Fourteenth Street Pumping Station 42

Photograph of Lake View Pumping Station 44

Photograph of Sixty-eighth Street Pumping Station .. 45

Photograph of Central Park Avenue Pumping Station .. 47

Photograph of Springfield Avenue Pumping Station 48

Photograph of Roseland Pumping Station 49

Photographs of Intake Cribs 52

Photograph of Interior of Edward F. Dunne Crib 56

Illustration Showing Comparison of Average Daily Consumption of Water per Person for Domestic Purposes with the Amount of Preventable Water Waste and Leakage in Chicago 137

Illustration Showing Size of One Year's Coal Supply for the Chicago Water Works 145

INTRODUCTION

The accompanying report on THE WATER WORKS SYSTEM OF THE CITY OF CHICAGO has been prepared in pursuance of authority granted to the Chicago Bureau of Public Efficiency July 13, 1914, by the Hon. Carter H. Harrison, Mayor, to investigate "the Bureau of Water and that part of the Bureau of Engineering which has charge of affairs connected with the water service of the city."

The inquiry was undertaken in September, 1914, but the completion of the report has been delayed by the pressure of more immediately urgent work.

The service of the Chicago Water Works and its efficiency are involved in two kinds of problems. First, there are those which result from the policies in conformity with which the business is conducted, such as general problems of finance, the problem of a pure water supply, and the problem of water waste and its prevention. Secondly, there are those problems that relate essentially to the efficiency of organization and of methods of administration.

In the preparation of this part of its report, the Bureau has considered only problems of the first group. Questions of organization and administration will be dealt with in another part of the report to be prepared and published in the future.

The most important problem which confronts the Chicago Water Works is that of water waste and its prevention. This is recognized by our own water works officials and by all other water works men familiar with existing conditions. These men also understand the so-

lution of this problem. No extended discussion of the subject is needed so far as they are concerned.

As yet, however, both the City Council and the general public have failed to understand and to appreciate either the ruinous effects of water waste upon service or the enormous financial loss which it involves.

The relief from present conditions, which has been long sought by the City Engineer and his assistants, must come through the City Council. The Council should assume the initiative. But complete success will be had only if back of the Council there is public support. To secure this will necessitate educating a considerable part of the public in the matter.

The principal value which a report of this kind can have is its educational value. In preparing it, therefore, the primary endeavor has been to avoid so far as possible the discussion of technical questions, and to set forth in non-technical form such information bearing upon the more important features of the water works system, its development, the general problems which it presents and their solution, as may be of interest to the public and as will serve as a basis for promoting public education and intelligent public opinion on these subjects. This applies particularly to the problem of water waste and to the question of universal metering, which the Bureau believes must be put into effect if the waste problem is to be satisfactorily solved.

Shortly after undertaking this water works inquiry, the Bureau arranged with Mr. John W. Alvord, Mem. Am. Soc. C. E., past president American Water Works Association, and a consulting engineer of national reputation, to make a preliminary survey of the entire situation and to advise with respect to the more important problems involved therein. During the preparation of

this report, also, the Director of the Bureau has had the opportunity of consulting freely with both Mr. Alvord and with his principal assistant, Mr. L. R. Howson. Mr. Alvord has examined the report since its completion and concurs in the conclusions reached, especially those relating to water waste and metering. The assistance thus rendered has been of very great value and any acknowledgment of it would be incomplete without a word of appreciation of the public spirit which animated it.

The Bureau wishes to acknowledge also the friendly and courteous co-operation and assistance invariably extended by the City Engineer, the Superintendent of Water, and their assistants.

CHICAGO BUREAU OF PUBLIC EFFICIENCY,
HARRIS S. KEELER,
Director.

December, 1917.

SUMMARY AND CONCLUSIONS

THE WATER WORKS PLANT

The Chicago water supply is drawn from Lake Michigan through six intake cribs located from two to four miles offshore. From the intake cribs the water flows by gravity through 50 miles of tunnels, varying from five feet to fourteen feet in diameter, to nine large pumping stations, where it is lifted by 45 pumping engines into the distribution mains, consisting of 2,800 miles of cast iron pipe, ranging from four inches to forty-eight inches in diameter, through which it is delivered to 300,000 taps serving approximately 2,500,000 people with over 600,000,000 gallons of water a day, a daily average of 259 gallons for each man, woman, and child in the City. This is more water than is supplied by any other water works system in the world.

WATER WORKS FINANCES

At the close of 1916 the original cost of the water works plant was approximately $70,000,000. This cost has been increasing rapidly during recent years, having practically doubled since 1901. Notwithstanding the fact that the pumping equipment, tunnels, and distribution mains are now far overbuilt for the reasonable requirements of the City, enlargements and extensions are progressing at the rate of about $3,500,000 a year. These extensions result from the policy of trying to cope with

the problem of water waste by constantly providing additional pumps and other equipment.

The revenue of the water works is now about $7,000,000 annually and is increasing at the rate of from $300,000 to $400,000 a year. In 1916, after deducting operating and maintenance costs, including depreciation, the water works business paid about 3.6 per cent on the capital outlay.

The excess of revenue over operating and maintenance costs, which represents the return on the public's invested capital, in recent years has amounted to from $2,500,000 to $3,000,000 annually. However, instead of the public profiting by this return through lower water rates, the money is being continually reinvested in extensions of the plant, which are necessitated by the excessive amount of water waste and leakage which prevail. Thus waste and leakage are depriving the community of a substantial part of the benefit which it should obtain through its ownership of the water works.

Since 1914, expenditures for additions to the plant and other purposes have far exceeded revenue, and the surplus in the water fund, which at that time was more than $4,000,000, has become so seriously impaired that during 1917 it has been necessary to issue water certificates. The Finance Committee of the City Council has also recommended a 20 per cent increase in water rates. The Council did not adopt this proposal, but such an increase will probably soon become unavoidable unless action is taken to curtail water waste and leakage and expenditures for plant extensions and other purposes are curbed.

The cost of constructing the water works has been financed principally with revenue derived from the sale of water and from miscellaneous sources. About ten

years ago, however, the City adopted the policy of levying a direct property tax for the redemption of bonds issued for water works purposes. Since this policy was inaugurated, more than $3,000,000 has been thus raised and applied in the payment of bond principal and interest. There are still outstanding about $2,000,000 of bonds issued for water works purposes, which are being redeemed from year to year with general tax moneys. This practice should be stopped. It serves to relieve the water fund of its legitimate obligations and in that way to make it possible for the City Council to divert water revenue to other uses. Levying a tax with which to pay water works obligations and then diverting the water fund to general corporate uses amounts to levying additional taxes for general corporate purposes by indirection, and is to be severely condemned.

Water Fund Diverted to Corporate Uses

One factor that has contributed to the present depleted condition of the water fund is the use of large sums of water revenue for other than water works purposes. On principle, a public utility like the water works should not be used to raise revenue for general corporate purposes. To sanction the practice is to invite extravagance and abuses. The law expressly provides that the water fund shall be used only for water works purposes. Generally, expenditures from the water fund for other City departments are made on the theory that such departments render service to the water works and that the cost of such service should be borne by that fund. This theory implies that the services rendered are necessary to the carrying on of the water works business. Obviously such charges should be limited to services of that kind and there should be a definite relation between the

value of the services rendered and the amount charged. Unfortunately, in the past that has not been the case and there is no definite assurance that it is so even now.

The most flagrant violation of both the spirit and the letter of the law prohibiting the use of water revenue for other than water works purposes is to be found in the expenditure of between $450,000 and $500,000 annually in recent years on account of the sewers and sewage pumping stations. Whatever might be said of the right to use the water fund to prevent sewage from polluting the water supply, the fact is that the expenditures now made from this fund are not for such purpose.

The Bureau recommends that in the future expenditures from the water fund be limited to water works purposes; also that steps be taken to establish definitely the value of services rendered to the water works by other departments, with a view to placing the transactions involved upon a businesslike basis.

THE PURITY OF THE WATER SUPPLY

Lake Michigan furnishes an unlimited quantity of water of a high degree of original purity. The trouble which Chicago has always had with its water supply has been due to the large amount of polluting matter which this City itself and neighboring cities and towns have discharged into the lake.

Efforts to avoid and counteract this pollution by locating the intake cribs as far from the shore as practicable; by keeping sewage and other contaminating matter out of the lake; and more recently by sterilizing the water with chlorine gas have greatly improved the quality of the supply.

Under present conditions the lake water at Chicago is exceptionally good a large part of the time without chem-

ical or other treatment. At other times it is badly polluted and unfit for drinking unless sterilized or otherwise purified. There are several well-defined sources of this pollution. None of them is continuous and uniform. All are occasional only and depend largely upon weather conditions and accidents of navigation. But that does not lessen the danger from them. In some ways it tends to increase the danger since it may produce a false sense of security.

It is not enough for water to be free from pollution the greater part of the time. It is essential that it be pure all the time. A water supply contaminated on four or five days in a year may result in serious epidemics. Fortunately, the public officials of Chicago realize these facts and are attempting to safeguard the supply against occasional pollution by sterilizing the water all the time.

Although occasional and chance pollution cannot be entirely eliminated, if freedom from water-borne disease alone were required sterilization probably would meet the situation. The use of chemicals, however, at times renders the water offensive to both taste and smell. The unpleasant taste and odor now frequently present in the water is due to the use of chlorine gas for purification purposes.

Sterilization, moreover, will not remove the muddy or turbid condition of the water which is frequently caused by the stirring up of the bottom of the lake by storms, and which always makes the water uninviting not only for drinking but for bathing and other domestic purposes. To obtain water free from turbidity, it will be necessary either to filter the present supply or to extend the intake cribs out into the lake to points twelve to fifteen miles offshore. In view of the uncertainty of obtaining water which is free from occasional pollution even

at these more distant points, and of the almost prohibitive cost of such extensions, it is considered impracticable to build them.

Public health authorities and the public generally are constantly demanding a higher standard of purity for domestic water supplies, and it is not to be expected that the people of this City will long be content with a supply which is inferior to that of other great cities of the world. It seems safe to predict, therefore, that in the not far distant future Chicago will demand water of greater purity and cleanliness, and that filtration, which will eliminate both the danger of bacterial impurities and turbidity, will be the means of obtaining such a supply.

WATER WASTE AND LEAKAGE AND THEIR PREVENTION

Notwithstanding the unlimited quantity of water close at hand and unusually favorable conditions for its distribution, there are constantly recurring complaints of a shortage of water and of insufficient pressure in various sections of the City.

The pressures which prevail are generally too low for efficient service. In most parts of the City, water is not being supplied above the third floors at any time. During periods when the demand for water is greatest there is a failure to supply third floors. In some sections of the City the service is not satisfactory and uninterrupted even on lower floors. Consumers who do not live near pumping stations or adjacent to large supply mains are frequently without water.

The inadequacy of the Chicago water supply is not due to any lack of pumping equipment but is due entirely to the vast amount of water lost through waste and leakage.

Waste and leakage are also causing enormous financial losses and have an important bearing upon the ultimate problems of filtration and of sewage disposal.

The Extent of Preventable Waste and Leakage

The average amount of water pumped daily during 1916 was 645,000,000 gallons. This pumpage was 14 per cent more than the entire supply of the City of (Greater) New York, the population of which is more than double the population of Chicago, and it is conceded by every person familiar with the situation that it was more than twice the quantity required to furnish Chicago an abundant supply for domestic, business, and other uses. In 1916, the amount of water pumped in Chicago was the equivalent of 259 gallons per day per person. Only one important city in the country—Buffalo—supplies more water per person than does Chicago. Cleveland and Milwaukee, both of which are lake cities and important industrial centers in which conditions of consumption are similar to those in Chicago, report a pumpage per person of 113 and 118 gallons per day, respectively. These figures are in striking contrast with the Chicago figures and indicate approximately the proportion of preventable waste and leakage which now exist in the Chicago system.

In a general way, it is known that only about 40 per cent of the water pumped in Chicago is *used* in the sense that it is consumed for some purpose for which water is necessary or has a real value, and that the remaining 60 per cent is lost in one way or another through waste and leakage. Part of this loss occurs in the course of the delivery of the water from the pumping stations to the premises of the consumers and results from leaks in pumps, distribution mains, and service pipes; part of

it occurs after the water is delivered to the consumers' premises and is occasioned by leaky pipes and plumbing fixtures and by wilful waste.

It is not practicable to distribute water without some leakage, particularly in the distribution mains and service pipes. Therefore, the waste and leakage in the Chicago system cannot be entirely prevented. By far the greater part of it can be eliminated, however.

It is believed that if effective waste control measures are adopted the pumpage per person can be reduced to 125 gallons per day. Such an allowance is considerably in excess of the pumpage of Milwaukee, Cleveland, and other cities under good waste control, and would provide an abundant supply for Chicago.

By reducing its pumpage to 125 gallons per person per day, Chicago will effect a daily saving of 330,000,000 gallons of water or the load of approximately 700 sixty-car freight trains. The saving which can be thus effected more than equals the combined supply of Milwaukee, Boston, Cleveland, and St. Louis.

Effects of Waste and Leakage

Besides its ruinous effect upon service, the transportation of the large volume of water lost through waste and leakage means a serious financial loss. There is an abundance of water in the lake and, of course, *the water itself is free,* but the City is in the business of transporting it from the lake to the premises of consumers and *its transportation costs money.* During 1916 it cost more than $1,000,000 *just to pump* water which is often regarded as free. It takes as much labor, coal, other supplies, and equipment to pump water into the sewers or into the ground as it does to furnish it for a useful purpose.

The financial loss results in two ways. Enormous expenditures are required for equipment which otherwise would not be needed. Moreover, more pumps and boilers must be operated and maintained. This means increasing the cost of pumping station labor, fuel, supplies, and repairs. It is now costing about $500,000 a year to pump water which is later wasted or which leaks away. In 1916, 190,000 tons of coal, valued at $450,000, were consumed in the Chicago pumping stations. One-half of this amount was used to pump water that was wasted. In view of the problems now involved in mining and transporting coal and of the resulting need for conserving its use, the necessity for preventing water waste, and hence fuel waste, is becoming more and more urgent.

Methods of Reducing Waste and Leakage

Efforts to reduce waste and leakage should be directed against losses both in delivery and on the premises of consumers. Reducing and holding such losses to a practical minimum in the mains and service pipes call for a systematic and continuous survey of the entire distribution system. So far as losses within the consumers' premises are concerned, they can be substantially eliminated. Keeping plumbing tight and shutting off the water when it is not in use are the important factors in controlling waste and leakage of this sort.

There are two methods of controlling waste on consumers' premises: one is by frequent house-to-house inspections; the other is by the installation of meters. House-to-house inspections are never completely effective. They are expensive and uneconomical. They produce only temporary results. They are generally burdensome and annoying to householders and to be even mea-

surably effective must be accompanied by the rigid enforcement of penalties.

METERING

Metering, on the other hand, is effective and the results obtained by it are permanent. Considering that its cost is about the same as the cost for house-to-house inspections, it is therefore by far the more economical method. It is also the equitable way to apportion water charges, since each consumer pays for the water that he takes and no more.

Notwithstanding its obvious advantages, there is generally a strong prejudice against metering wherever it has not been adopted. It is significant, however, that cities in which meters have been installed have not gone back to former methods, the meters having proved satisfactory both to the municipality and to the consumers. Milwaukee and Cleveland are typical examples.

The opposition to metering is due largely to prejudice and to a lack of information as to the results which follow the installation of meters. There is a generally prevalent belief that meters result in restricting the customary use of water, or that, in the absence of such restricted use, water bills will be increased.

Meters Do Not Restrict the Use of Water

Experience has demonstrated, however, that where meters have been introduced they neither restrict the use of water nor increase water bills. They produce results not by restricting usage, but by preventing waste and leakage. It should be clearly understood that preventing waste and leakage means reducing so far as practicable the loss of water through leakage and other causes, and

that it does not mean curtailing or restricting any person in his accustomed use of water. What is desired is to stop pumping and distributing an enormous volume of water that is of no use to any one. It is neither necessary nor desirable to restrict the use of water. It should be supplied in abundance and its use encouraged. With practically every consumer exercising care to eliminate waste, water can be furnished so cheaply that no one need think of restricting the amount of which he can make any use. Metering is advocated for Chicago partly because it is the most effective means of insuring an abundant supply under sufficient pressure to enable all consumers to obtain promptly and at all times the water which they require and are entitled to for their legitimate uses. Such a condition has never existed in Chicago.

Meters Do Not Increase Water Bills

Experience shows also that where rates are properly adjusted meters do not result in increasing water bills in the majority of cases. A few illustrations will demonstrate this. The flat rate charge in Chicago which is applicable to thousands of small houses is $5.64 a year; if a hose is used the charge is $7.14. An ordinary two-flat building is charged $10.88 a year; if a hose is used the charge is $12.38. About two-thirds of all consumers in Cleveland pay $5 a year or less. In Milwaukee, where no minimum charge obtains, nine-tenths of the consumers pay less than $10 for their year's supply; three-fourths of them pay less than $5 a year; and half pay less than $3 a year. The records of Oak Park, Illinois, which is a high class residential community, the people of which use water lavishly, show that at the Chicago meter rate of 6¼ cents per thousand gallons, three-fourths of the consumers would pay less than $5 a year.

The Oak Park records also show that at the Chicago meter rate the average yearly charge for residences in Oak Park would be approximately $4 per year and the average charge for apartment buildings of all sizes would be about $8.50 per year. These figures should be particularly interesting to Chicago property owners who are paying substantially double these amounts for the same quantity of water in the same class of buildings.

In three sections of Chicago where meters heretofore have been installed in residences and two-flat buildings, the records show that the average yearly charge per residence is $4, $4.50, and $6.70, respectively; also that a very large number of consumers pay less than $4 a year. The accounts covering 100 two-flat buildings show an average charge of $5.70 per year.

Landlords are generally among the opponents of meters, because they fear that their bills will be increased by the wasteful and careless practices of their tenants. But experience also has shown that this fear is not well founded; that the number of tenants who wilfully waste water is not large; and that, where the landlord complies with the ordinances of the City requiring plumbing to be kept in repair, he has no reason for apprehending that the installation of a meter will penalize him. In many cases the landlord would save money by having a meter installed, and the City officials report that the owners of small apartment buildings who are cognizant of this fact frequently request meters for buildings which under the ordinances are not required to be metered.

Universal Metering Recommended

The Bureau recommends that the City authorities at once establish universal metering as a policy, and that they take the necessary steps to put it completely into

effect during the next ten years. It is important to adopt a policy of universal metering and to preserve its continuity, because until such a policy is definitely established water works officials will be obliged to continue constructing additions to the plant to meet waste conditions which will have to be faced in the future.

The meters should be owned by the City and should be installed and maintained free of expense to consumers.

The Bureau believes that in putting universal metering into effect the meter rate of 6¼ cents per thousand gallons, which is now charged, should be retained for the present, and that reasonable minimum rates should be established. This will result advantageously to thousands of small property owners and will not materially impair the water revenue. By minimum rates is meant that owners or consumers should be required to pay for a certain amount of water whether or not they use it. For all water used in excess of the quantity which the minimum charge will purchase, they will then pay at the usual rate. Such minimum rates should be substantially lower than the present rates, so that consumers, if they are careful to avoid waste and leakage, can save money without in any way using less water than they are now accustomed to use. Again, they should be high enough to encourage the use of all the water which health and comfort call for, by requiring consumers to pay for all the water that they need whether they actually use it or not.

The Saving to be Effected by Universal Metering

The improved service which will result from universal metering, supplemented by the repair and rehabilitation of the distribution system, will be the important primary benefit. There can be no doubt, however, that metering will be profitable as a business proposition.

If waste and leakage are brought under effective control during the next ten years, the pumpage of the Chicago Water Works can be reduced to 425,000,000 gallons per day by 1928, as compared with 645,000,000 gallons per day in 1916; and further, the daily pumpage can be kept considerably below the 1916 figure as late as 1950.

This reduction in pumpage will make possible an immense saving in expenditures for water works plant. It will mean that additional tunnels, cribs, and pumping stations will not be needed for thirty-three years. The reduced pumpage will also effect very large savings in operating and maintenance costs.

The Bureau estimates that the saving in interest and depreciation charges, which can be effected during the next thirty-three years by reducing the necessity for capital outlays for new pumping stations, cribs, tunnels, and other equipment, will aggregate $66,000,000, and that the further saving which can be effected in operating costs during that time will be $69,000,000. Thus the total saving which will result from universal metering will aggregate $135,000,000 between now and 1950. The savings estimated are net, deductions having been made both for the cost of installing and for reading and maintaining the meters.

The cost of installing meters will aggregate approximately $9,000,000 during the first ten years and $200,000 per year thereafter. The annual cost of reading and repairing meters will average approximately $290,000 per year for the first ten years and $575,000 per year thereafter.

The following table shows also the estimated savings which can be effected for periods of ten and twenty years. It will be noted that in the first ten years not only will universal metering save $7,600,000 but that under it the

estimated amount of capital necessary for investment in plant will be $15,000,000 less than will be required if present conditions of waste continue. This difference of $15,000,000 in capital outlay is net, allowance having been made for the entire cost of installing the meters.

Table Showing Estimated Additional Capital Which Will Be Required to Construct Water Works Plant If Universal Metering Is Not Adopted; also Estimated Saving Which Can Be Effected by Universal Metering During Different Periods Beginning in 1918

	10 Years	20 Years	33 Years
Additional Capital to be Required in Absence of Universal Metering	$14,950,000	$46,850,000	$94,000,000
Saving to be Effected by Universal Metering—			
Interest at 4%.....	$2,830,000	$15,390,000	$53,000,000
Depreciation at 1%.....	710,000	3,850,000	13,000,000
Ordinary Operating and Maintenance Charges	4,060,000	22,660,000	69,000,000
Total Saving to be Effected by Universal Metering During Respective Periods.*	**$7,600,000**	**$41,900,000**	**$135,000,000**

*No attempt has been made to estimate the further saving to be effected by avoiding the loss which will result after the expiration of the respective periods from the destruction or deferred use of the additional capital which will have to be invested if universal metering is not adopted. See pages 202-3.)

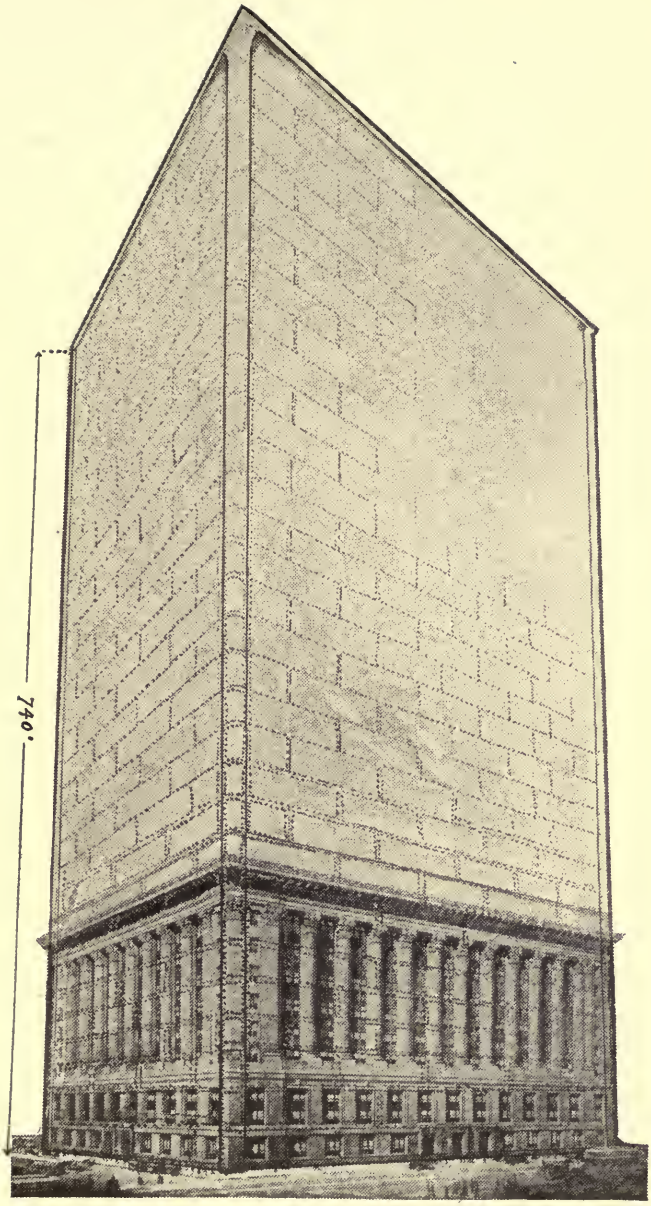
RESPONSIBILITY FOR EXISTING CONDITIONS

The City Engineer and other administrative officials for more than fifteen years have been urging the City Council to authorize metering as the only means by which permanent relief from waste and leakage, and the resultant inefficient service and financial loss, can be obtained. The Mayor and the Aldermen, however, have thus far

failed to support these appeals in anything like an adequate way.

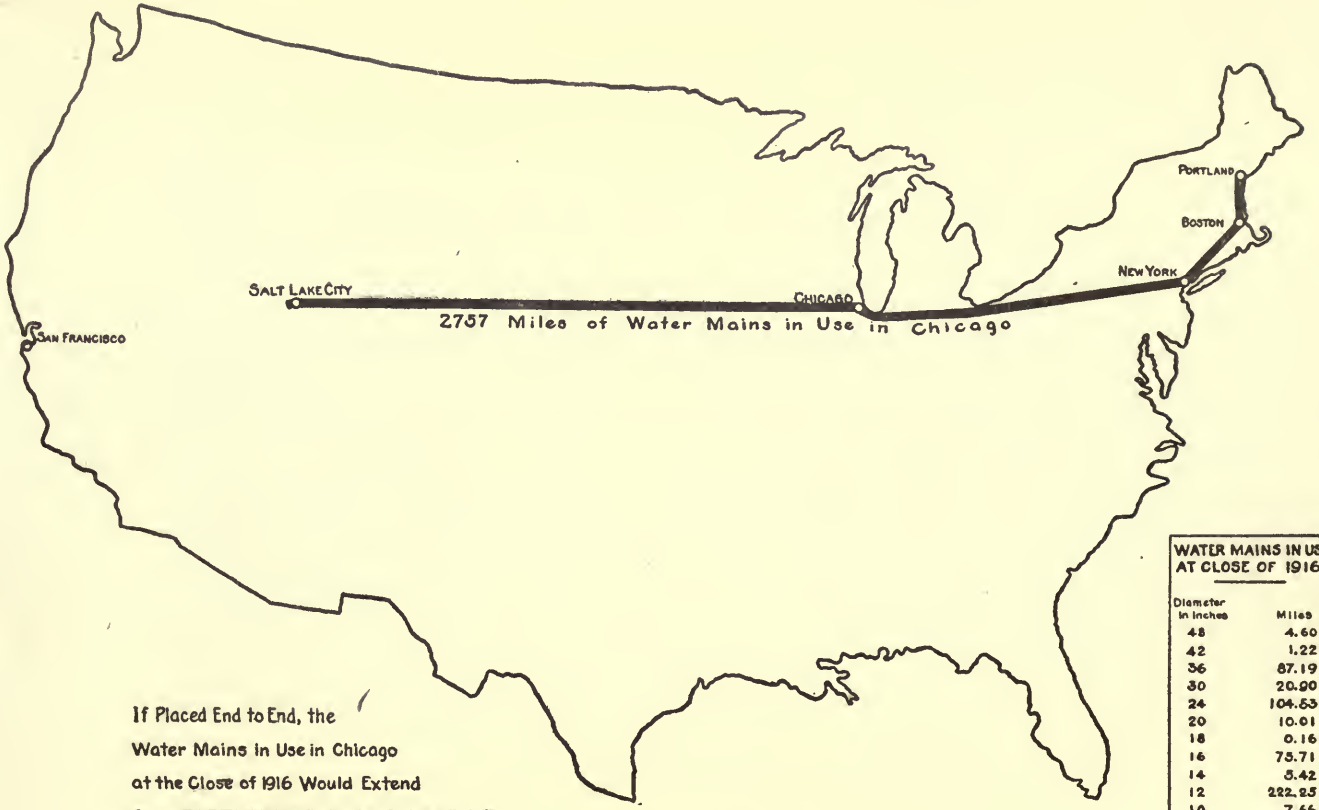
The public also is quite generally either apathetic or antagonistic to the idea of metering. This is because the public, for the most part, is not acquainted with the facts concerning the effect of meters both upon the use of water and upon water bills. Experience shows that a meter will neither increase the water bill of the ordinary householder nor restrict him in his customary use of water and that meters produce results entirely by eliminating waste and leakage, thus obviating the necessity for providing equipment with which to pump and distribute an enormous volume of water that serves no useful purpose.

The City Council should recognize this state of affairs and should accept the responsibility for remedying the existing situation by initiating and carrying out a program for universal metering. In this undertaking, the Council should have the earnest and active support of every householder, tenant, and property owner in the City.



RESERVOIR THAT WOULD BE REQUIRED TO HOLD ONE DAY'S PUMPAGE

The average amount of water pumped every day in Chicago would fill a reservoir three and one-half times the size of the City Hall and County Building combined. This is more water than is supplied by any other water works system in the world.



If Placed End to End, the
Water Mains in Use in Chicago
at the Close of 1916 Would Extend
from PORTLAND, ME. to SALT LAKE CITY

Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

WATER MAINS IN USE AT CLOSE OF 1916

Diameter in Inches	Miles
48	4.60
42	1.22
36	87.19
30	20.90
24	104.53
20	10.01
18	0.16
16	75.71
14	5.42
12	222.25
10	7.66
8	878.
6	1270.24
4	69.56
3	0.27
Total Miles -	2757.72

THE WATER WORKS SYSTEM
of the
CITY OF CHICAGO

The Chicago Water Works pumps more than six hundred million gallons of water daily. This is more water than is supplied by any other water works system in the world.

The quantity of water pumped each day would fill a reservoir three and one-half times the size of the City Hall and County Building combined. The City's water mains if placed end to end would extend from Portland, Maine, to Salt Lake City—four-fifths of the distance across the country. These comparisons help to visualize both the vastness of the service rendered by this municipally owned and operated utility and the enormous extent of the system itself.

I. GENERAL DESCRIPTION OF THE PLANT

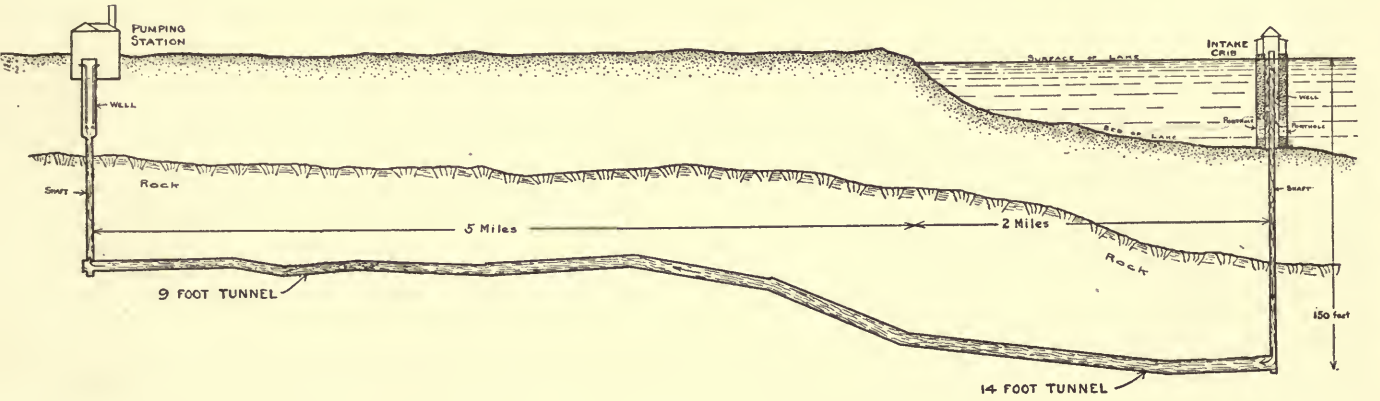
Lake Michigan is the only source of supply. The water flows by gravity through tunnels from intake cribs, located from two to four miles off the lake shore, to pumping stations where it is forced into the distribution mains by the pumps.

There are six intake cribs and approximately 50 miles of lake and land tunnels varying in diameter from five feet to fourteen feet. The total capacity of these tunnels under normal conditions is approximately 1,117,000,000 gallons per twenty-four hours.

Table Showing Dimensions of Chicago Water Tunnels; also Names of Intake Cribs, Normal Capacities of Tunnels, and Year When Each Was Put Into Service

Name of Tunnel	Year Put Into Service	Diameter in Feet	Length in Miles	Approximate Capacity under Normal Conditions Gals. per 24 Hrs.*	Intake Crib
Chicago Avenue 5 foot Lake Tunnel	1867	5	2.01		
North Shore Extension Tunnel	1896	7	2.01	126,500,000	Two-Mile Crib
Chicago Avenue Pumping Station Tunnels		5 6 7	.28		
Chicago Avenue Extension Tunnel	1900	5 6 7	.30	**	
Lake Extension—Cross-Town Tunnel	1875	7	2.05		
Blue Island Av. Tunnel	1909	6 7 8	5.60	90,500,000	Two-Mile Crib
Lake Extension—Blue Island Connecting Tunnel	1913	8	.23		
Four-Mile Lake Tunnel	1892	6 8	6.62		
Fourteenth Street Station Tunnels	1892	6 8	.50	125,000,000	Four-Mile Crib
Polk Street Tunnel	1907	6 7	1.71		
Lake View Tunnel	1896	5 6	2.03	75,000,000	Lake View Crib
Sixty-eighth Street Tunnel	1894 1898	5 7	3.91	100,000,000	Sixty-eighth St. Crib
Northeast Lake and Northwest Land Tunnels	1900	8 10	12.26	200,000,000	Carter H. Harrison Crib
Southwest Lake and Land Tunnels	1911	9 12 14	10.11	400,000,000	Edward F. Dunne Crib
Sixty-eighth St. Connecting Tunnel	1916	6 8	.58		
Total			50.2	1,117,000,000	

* Based upon estimates of City Engineer in report of Nov. 16, 1911.



Prepared by CHICAGO BUREAU OF PUBLIC EFFICIENCY - 1917

Typical profile showing how the water of Lake Michigan flows from an intake crib to a pumping station well from which it is lifted by pumping engines and forced into the distribution mains.
(For illustration purposes, the horizontal scale at the station and crib is disregarded.)

There are nine large pumping stations, housing 43 pumps, having a total maximum daily rated capacity of 948,000,000 gallons. There are also two minor stations —a small booster station, with a maximum daily rated capacity of 7,000,000 gallons, which repumps water for the high level territory in the extreme northwest section of the City, and the Rogers Park station designed for use in emergency only to aid in supplying the Rogers Park district.

Table Showing the Chicago Water Pumping Stations; the Year When Built; the Number of Pumps Operated; the Maximum Rated Daily Capacity; the Greatest Amount Pumped During Any One Day in 1916; and the Average Daily Pumpage During 1916

Name of Station	Year When Built	No. of Pumps	Maximum Rated Daily Capacity in Gallons Dec. 31, 1916	Greatest Amount Pumped in Any One Day During 1916 (Gallons)*	Average Daily Pumpage in 1916 allo
Chicago Avenue .	1869	5	99,000,000	91,377,800 (Jul. 28)	74,324,890
Twenty-second St.	1876	6	110,000,000	102,008,300 (Dec. 21)	79,951,557
Harrison Street ..	1890	3	55,000,000	47,454,649 (Aug. 5)	34,557,623
Fourteenth Street.	1892	5	100,000,000	89,962,700 (Apl. 18)	78,473,333
Lake View.....	1875 \ 1909–15/	4	100,000,000	80,372,850 (Aug. 21)	51,043,524
Sixty-eighth St. ..	1882	6	134,000,000	113,048,332 (Dec. 23)	90,001,530
Central Park Ave.	1900	5	125,000,000	103,361,730 (Aug. 31)	86,482,295
Springfield Ave...	1901	5	125,000,000	111,980,350 (Aug. 21)	88,730,573
Roseland.....	1912	†4	†100,000,000	96,701,580 (Aug. 19)	61,624,234
Total Nine Major Stations.....		43	948,000,000		645,189,559
Jefferson Park (Booster).....	1912	3	7,000,000	5,740,000 (Aug. 7 & 21)	3,441,584
Rogers Park ** ..	1889	2	3,500,000	Not in Operation in 1916	
Grand Total All Stations ..		48	958,500,000	759,451,412 (Aug. 21) ***	648,631,143

* Pumpage by plunger displacement; no allowance made for slippage.
** Operated in emergency only.
*** Not a total of this column, but the greatest amount of water pumped on any one day by the entire plant.
† Two 5,000,000-gallon booster pumps which repump water for high level territory in southwest section of city not included.

NOTE—The greatest amount of water pumped on any one day during 1917 was 772,000,000 gallons on December 11.

While the aggregate rated capacity of the pumps at the major pumping stations as shown by the foregoing table is 948,000,000 gallons, it should be borne in mind that several of these pumps represent reserve equipment and that because of inadequate tunnel capacity at some of the stations all the pumps cannot be operated to full capacity at the same time. The actual maximum capacity of the plant under present conditions is probably about 800,000,000 gallons per day.

It will be seen from the accompanying map that all but one of the earlier stations were located along the shore of Lake Michigan. For various reasons these stations undoubtedly would have been differently located had the entire system been planned at one time, but financial and other considerations have seemed to make it inexpedient to change their locations. It will be noted, however, that in recent years the practice has been to locate stations farther inland, near the center of the district which they are designed to serve. This reduces the distance which the water has to be pumped and thus reduces the cost of pumping.

A tenth major pumping station—the Mayfair station, located at Wilson and North Lamon Avenues—is now nearing completion and still another station, to be located in the vicinity of Sixty-first Street and Western Avenue, is under consideration.

The present area of the City of Chicago is 200 square miles. All but approximately 15 square miles of this area is supplied with water by the system of distribution mains which gridiron the City. At the close of 1916 there were 2757 miles of these cast iron pipes varying in diameter from four inches to forty-eight inches. The entire system is interconnected, except those parts in the northwest and southwest sections of the City which are

supplied by the Jefferson Park "booster" station and the "booster" pumps of the Roseland station, respectively. (See pages 49, 50.)

Table Showing the Length in Miles of the Various Sizes of Water Mains in Service in the City of Chicago December 31, 1916

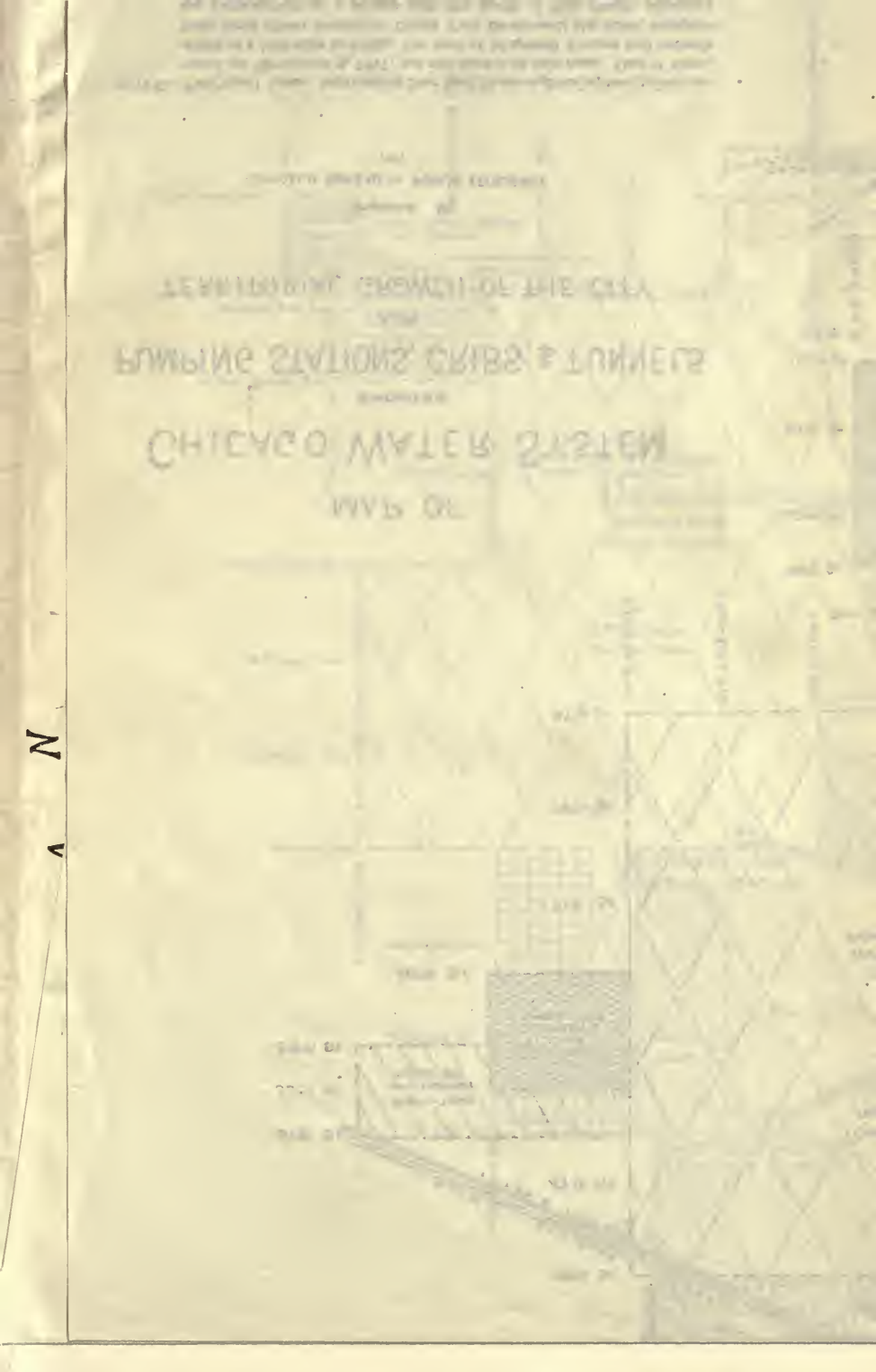
Diameter in Inches	Length in Miles	Diameter in Inches	Length in Miles
3	0.27	16	75.71
4	69.56	18	0.16
6	1270.24	20	10.01
8	878.	24	104.53
10	7.66	30	20.90
12	222.25	36	87.19
14	5.42	42	1.22
		48	4.60
		Total.....	2,757.72

There are approximately 300,000 active service pipes leading from the distribution mains to the premises of the consumers. About 7 per cent of these services are metered.

II. THE HISTORICAL DEVELOPMENT OF THE WATER WORKS SYSTEM

The Chicago water works system as a municipal project had its beginning in 1851 when the Legislature empowered the City to establish its own water works.

The City of Chicago was incorporated in 1837, but it was not until 1842 that any attempt was made to operate a



water works plant. In that year the Chicago Hydraulic Company, a private corporation, undertook to furnish a small portion of the City with water by means of a 25 horse-power pumping engine and an elevated reservoir situated at Lake Street and Michigan Avenue. The water mains were logs with holes bored through their centers. Even after this plant began to operate, a large part of the City was still supplied with water from wells and from water carts.

PUMPING STATIONS

Chicago Avenue Station

Shortly after the City had acquired the right to establish its own water works, it took over the equipment of the private company and immediately commenced work upon a new plant.

A pumping station was erected on the site of the present Chicago Avenue station at Chicago Avenue and Lincoln Parkway and in 1853 a new pumping engine with a daily capacity of 8,000,000 gallons was put into service. The water was taken from Lake Michigan a short distance from the shore and was distributed through three reservoirs one of which was located on each of the three sides of the City.

As will be seen from the accompanying map, the original City limits were extended in 1847, 1853, 1863, 1869, and 1887, respectively. The increased demand for water resulting from the annexation of new territory and the rapid growth in population necessitated new pumping machinery soon after the first pump had been put into operation.

To meet this and subsequent demands for water arising from the recurrence of similar conditions, additional

CHICAGO AVENUE PUMPING STATION

Chicago Avenue and Lincoln Parkway

This station is located on the site of the first pumping station erected by the City. The original station was built in 1853. The present station building and water tower were finished in 1869. The buildings were damaged by the great Chicago fire of 1871, but were restored and have not since been materially changed. The water tower is no longer in use, but is preserved as a landmark. The station contains five pumping engines having a total capacity of 99,000,000 gallons a day.

pumping engines were installed from time to time at this station until in 1887 it had a maximum capacity of 99,000,000 gallons per day.

Meanwhile, beginning in 1864, the old buildings had been gradually demolished and a new station and water tower built. The pumping station, which was completed in 1869, was damaged by the great Chicago fire of 1871, but was repaired and is still standing, although in remodelling the plant and in installing new engines and other equipment it has been necessary from time to time to make extensive interior alterations and also to erect some additions to the building. The water tower has been preserved as a landmark, but its use was discontinued years ago and the standpipe removed in 1911.

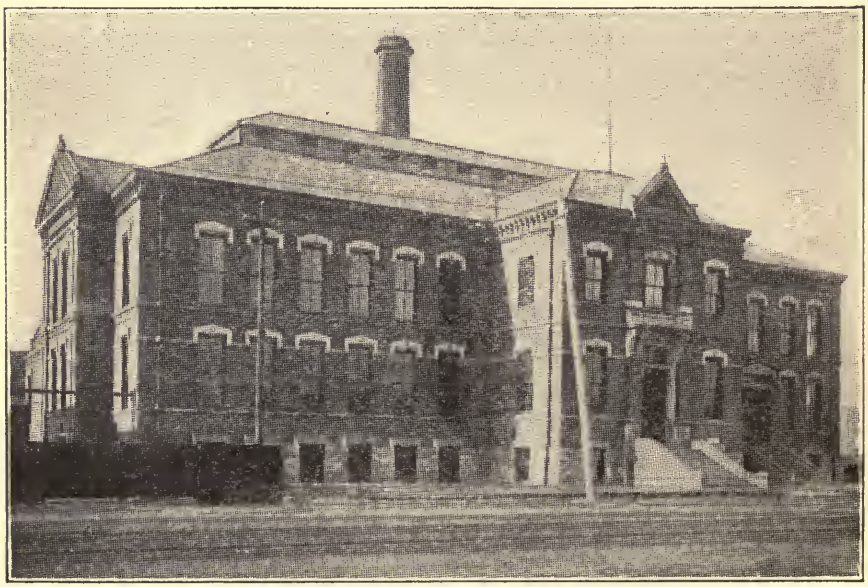
Two pumping engines installed in 1887, each having a rated capacity of 12,000,000 gallons per day, are still in service. Beginning in 1904, however, all the earlier pumps were replaced by three modern pumping engines each having a rated capacity of 25,000,000 gallons per day.

Twenty-second Street Station

With the extension of the City limits west to Fortieth (Crawford) Avenue in 1869, it became apparent to the City authorities that a pumping station must be located farther inland since the friction in the pipes due to forcing the water the long distance from the pumping station, located on the lake shore, to the western limits, was so great that the pressure was nearly all lost when the water reached that part of the City. Accordingly, a second pumping station was erected on Ashland Avenue south of Twenty-second Street. It was equipped with two pumping engines each with a rated capacity of 15,000,000 gallons per day, which were first put into opera-

tion in November, 1876. In 1884 two new engines, each having a daily capacity of 15,000,000 gallons, were added to the equipment. Three of these engines are still being operated and have been in service continuously since they were installed. One of the 1876 engines has been recently removed, preparatory to installing two new electrically driven centrifugal pumps of 25,000,000 gallons capacity each.

In 1912 two electrically driven centrifugal pumps, each with a daily capacity of 25,000,000 gallons, were added to the equipment. The present maximum rated capacity of this station is 95,000,000 gallons per day.



TWENTY-SECOND STREET PUMPING STATION

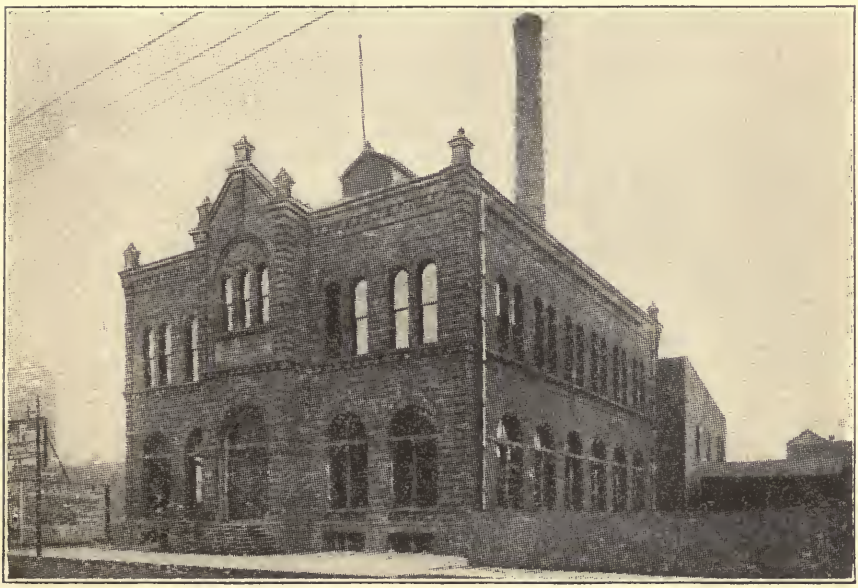
Ashland Avenue, south of Twenty-second Street

Chicago's second pumping station, erected in 1876 and enlarged in 1884, houses five pumping engines having a total capacity of 95,000,000 gallons a day. One of these pumps has been in service continuously since 1876; two were erected in 1884. The remaining two which are electrically driven were installed in 1912. This station supplies the territory lying largely between Halsted Street and Western Avenue, south of Twelfth Street, including the Union Stock Yards.

Harrison Street Station

By 1886 the increasing demand for water necessitated the construction of two new pumping stations—the Harrison Street station and the Fourteenth Street station.

The former, which is located on Harrison Street east of Halsted Street, was equipped with two pumping engines each having a rated capacity of 15,000,000 gallons per

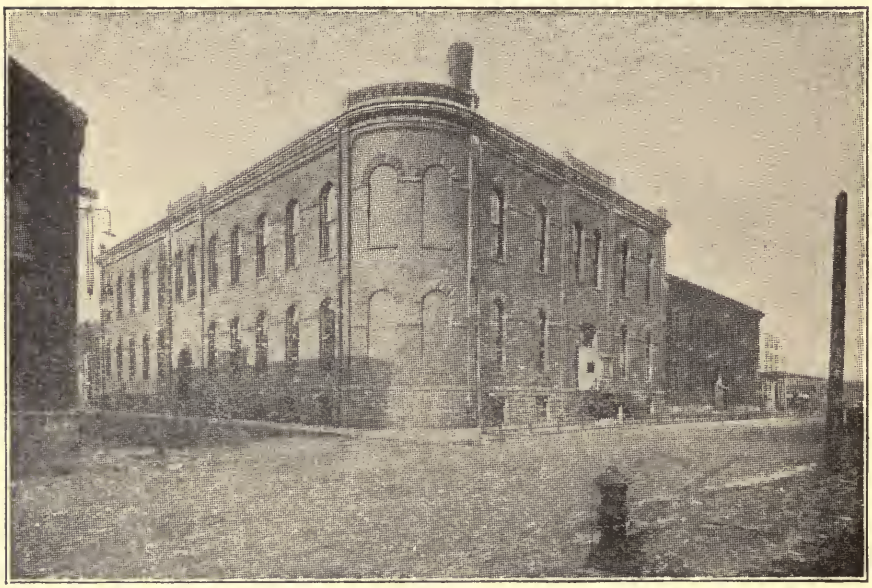


HARRISON STREET PUMPING STATION
Harrison Street, east of Halsted Street
Erected in 1890. The capacity of its three pumping engines aggregates 55,000,000 gallons a day.

day. These pumps were put into operation in July, 1890, and are still in service. During 1913 a 25,000,000 gallon steam-driven centrifugal pumping engine was installed to furnish reserve equipment. Except for the installation of this additional pump and new boilers, there has been but little change in the equipment of this station since its erection in 1890.

Fourteenth Street Station

The Fourteenth Street station, work on which was begun in 1888, was finally put in service in December, 1892. At that time it was equipped with three pumping engines, each having a rated capacity of 15,000,000 gallons per day. In 1898 a fourth pumping engine with a capacity of 30,000,000 gallons was installed.



FOURTEENTH STREET PUMPING STATION

Fourteenth Street and Indiana Avenue

Erected in 1892. Contains five pumping engines having a total capacity of 100,000,000 gallons a day. This station, together with the Chicago Avenue and Harrison Street stations, supplies the "loop" district of the City.

In 1913 a 25,000,000 gallon steam turbine driven centrifugal pump, designed primarily to furnish reserve equipment, was installed at this station. Except for the installation of new boilers and other necessary repairs and replacements and also some rather extensive altera-

tions to the building and auxiliary equipment which were made in 1913 and 1914, the installation of the additional pumps in 1898 and 1913 constitute the principal changes in this station since its erection.

Further Extension of the City Limits in 1889

The area of the City of Chicago at the time of its incorporation in 1837 was about 10½ square miles. The several extensions of the City limits between that date and June 29, 1889, had increased the area to about 44 square miles. On this latter date there were annexed to the City 126 square miles of additional territory. This additional territory included the City of Lake View, the Village of Hyde Park, the Town of Lake, a part of the Town of Jefferson, and a part of the Town of Cicero.

Lake View Station

At the time of its annexation in 1889, the City of Lake View was operating a pumping station which was located on the site of the present Lake View station at Montrose and Clarendon Avenues. This station had been constructed in 1875, and when taken over by Chicago at the time of annexation its pumps had a total rated capacity of 19,500,000 gallons per day. In 1892, 1897, and 1909, additional pumps with capacities of 12,000,000 gallons, 14,000,000 gallons, and 25,000,000 gallons per day, respectively, were installed.

The installation of the 1909 pump marked the beginning of the general rehabilitation of this station, including the erection of four modern pumping engines, each with a rated capacity of 25,000,000 gallons per day, together with a new boiler house, coal storing and handling equipment and other appurtenances. The work of reconstructing the station costing approximately $1,400,000 was practically completed during 1915.

LAKE VIEW PUMPING STATION

Montrose and Clarendon Avenues

This station is located on the site of the original water works of the City of Lake View, erected in 1875 and acquired by Chicago through annexation in 1889. The present station, which houses four modern pumping engines having a total capacity of 100,000,000 gallons a day, was constructed between 1909 and 1915.

Sixty-eighth Street Station

At the time of their annexation to Chicago in 1889, the Village of Hyde Park and the Town of Lake were each operating a station on the present site of the Sixty-eighth Street pumping station on Sixty-eighth Street, a short distance west of South Shore Boulevard.

The Town of Lake station had been built in 1873 and had supplied water for both the Town of Lake and the Village of Hyde Park until 1882 when the water works of these two municipalities were separated and Hyde Park began to operate its own plant. Both of these stations were taken over by the City. Following annexation, the Town of Lake station was abandoned. The Hyde Park

station was enlarged and additional pumping equipment has been added from time to time. The existing equipment has a rated daily capacity of 134,000,000 gallons. The present plan of the City authorities contemplates the replacement, within the next few years, of this station (now known as the Sixty-eighth Street station) by a new station to be erected at Seventy-third Street and Stony Island Avenue. Pending the construction of this new station, the capacity of the old pumps at the Sixty-eighth Street station has been reinforced by the installation of two steam-driven centrifugal pumps, each with a daily capacity of 30,000,000 gallons, which were put into operation in the fall of 1916.

SIXTY-EIGHTH STREET PUMPING STATION

Sixty-eighth Street and Oglesby Avenue

Like the Lake View station, this station was acquired by annexation in 1889. Originally constructed in 1882 by the Village of Hyde Park, it was enlarged in 1891 and again in 1905, the first enlargement being to accommodate additional equipment to supply the World's Columbian Exposition. The capacity of the present station is 134,000,000 gallons a day.

Territory Annexed Since 1889

Since 1889 approximately 30 square miles of territory have been brought within the City limits. The several sections annexed from time to time are shown on the map opposite page 37.

In 1890 South Englewood and the Villages of Gano, Washington Heights, and West Roseland were brought into the City, and in 1891 the Village of Fernwood was added.

In 1893 the Villages of Rogers Park, West Ridge, and Norwood Park were annexed.

In 1895 a small part of the township of Calumet was added.

In 1899 a portion of the township of Cicero, including the section known as Austin, was annexed.

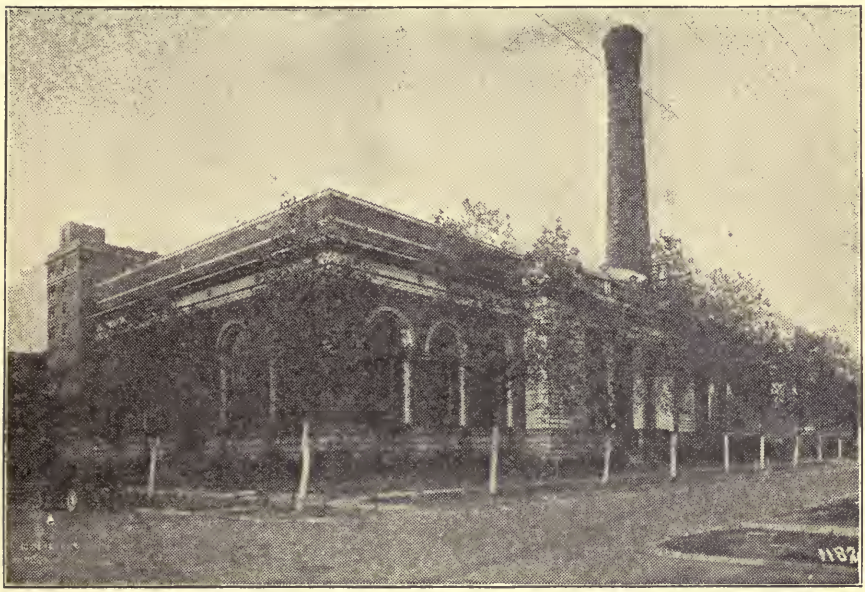
There were no further annexations until November, 1910, when the Village of Edison Park became a part of the City. The more recent additions are Morgan Park in 1914; and the Village of Clearing, a part of the township of Stickney, and small sections of the townships of Evanston, Niles, and Calumet in 1915.

The last territory joined to the City consists of two small areas, aggregating one and three-eighths square miles, which were annexed on November 6, 1917. One of these sections, which is a half-mile in width, lies west of Maynard Avenue and extends from Bryn Mawr Avenue to Irving Park Boulevard; the other, comprising three-eighths of a square mile, lies north of Sixty-fifth Street, adjoining the former Village of Clearing on the west.

Central Park Avenue and Springfield Avenue Stations

It was thought that the completion of the Fourteenth Street and Harrison Street pumping stations in 1890-92, together with the four-mile tunnel from which they drew

their supply, would insure an abundant quantity of water for all purposes for a long time to come, but within three years the lack of water in various sections remote from the lake, especially on the west and northwest sides of the City, had resulted in the planning of two new pumping stations and another tunnel. One of these stations—the



CENTRAL PARK AVENUE PUMPING STATION

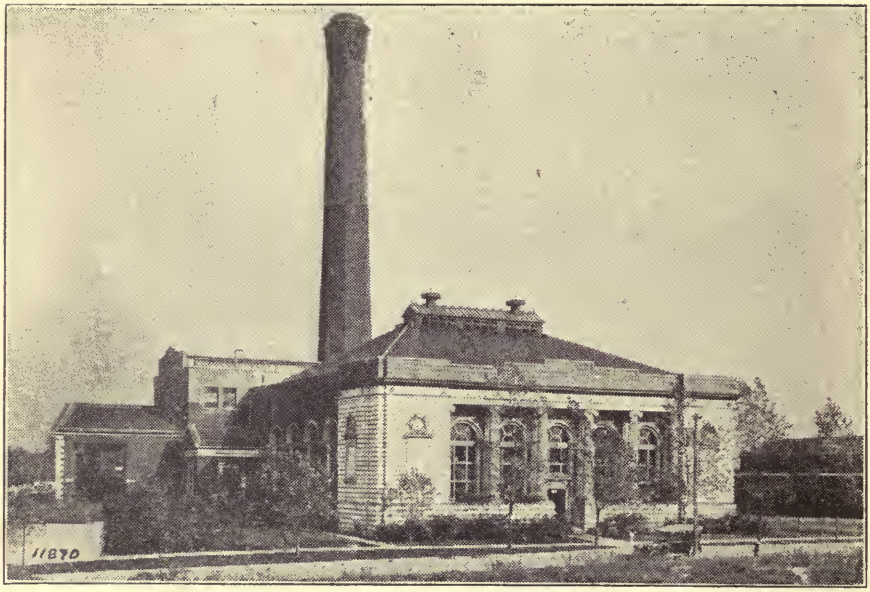
Central Park Avenue and Fillmore Street

This station was completed and put into service in 1900. The total capacity of its five pumping engines is 125,000,000 gallons a day.

Central Park Avenue station—is located at Central Park Avenue and Fillmore Street; the other—the Springfield Avenue station—is located at Springfield and Bloomingdale Avenues. These stations are substantially counterparts of each other. They were completed and put into operation in 1900 and 1901, respectively. Each was originally equipped with three pumping engines with a

total daily rated capacity of 60,000,000 gallons. In 1907 another pumping engine with a daily rated capacity of 40,000,000 gallons was added to the equipment of each station.

In 1913 a steam turbine driven centrifugal pump with a rated capacity of 25,000,000 gallons per day was in-



SPRINGFIELD AVENUE PUMPING STATION

Springfield and Bloomingdale Avenues

This station, erected at the same time as the Central Park Avenue station, is practically a counterpart of the latter as to equipment. It was put into service in 1901.

stalled at each station. These latter pumps are intended to provide reserve equipment.

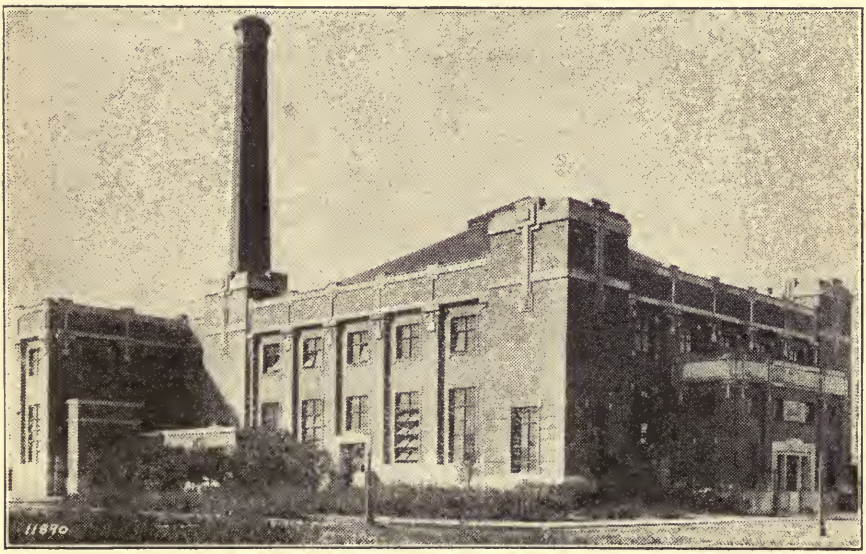
Roseland Station

The Roseland pumping station, located at One Hundred and Fourth Street and Stewart Avenue, is the only major pumping station added to the plant since 1901. This

station has been in operation since 1912. It supplies the extreme southern and southwestern sections of the City, which were formerly supplied by the Sixty-eighth Street station.

This is a thoroughly modern station with a maximum daily rated capacity of 100,000,000 gallons. Originally, two pumping engines, each with a maximum daily rated capacity of 25,000,000 gallons, were installed, but in 1915 two additional engines of similar design and capacity were put into operation.

This station is also equipped with two steam-driven centrifugal booster pumps, each with a capacity of 5,000,000 gallons per day. Since the latter part of 1914 these booster pumps have been repumping water to supply



ROSELAND PUMPING STATION

One Hundred and Fourth Street and Stewart Avenue

This station, which has been in operation since 1912, was the ninth major pumping station to be erected. Its four pumping engines have a total daily capacity of 100,000,000 gallons. It also houses two booster pumps which repump the water to supply the high level area in the Washington Heights district.

the high level district adjacent to, and formerly supplied by, the Washington Heights station.

Norwood Park, Edison Park, and Jefferson Park Stations

At the time of their annexation to the City, the Villages of Norwood Park, Edison Park, Rogers Park, Washington Heights, and Morgan Park were each operating independent water works plants. Except in the case of Rogers Park where the water was taken from the lake, the water supply of these municipalities was drawn from artesian wells.

The City continued to operate the Norwood Park and Edison Park stations until December, 1912, when the territory which they supplied was added to the system of the Jefferson Park station, a small "booster" station erected during that year to supply the high level territory in the northwest section of the City.

Rogers Park Station

The Rogers Park station was owned and operated by a private company until 1907 when it was taken over by the City. Besides water pumping engines, this station was also equipped with air compressors which were operated in connection with the sewage disposal system. The City has continued to operate these air compressors. The water supply pumps were also operated until October, 1914, when they were closed down, the district contiguous to the station then being supplied from the Lake View station. During 1916, however, a new electrically driven centrifugal pump was installed, designed for use as occasion might require when the supply provided for the Rogers Park district by the Lake View station was inadequate. Because of the contaminated condition of the lake water at the Rogers Park intake, it has been found impracticable so far to operate this pump.

Washington Heights Station

The Washington Heights pumping station was continued in operation until October, 1914, when the district which it had been supplying was transferred to the pumps at the Roseland pumping station above described.

Morgan Park Station

The Morgan Park pumping station was abandoned almost immediately after its acquisition by the City. The territory which it had supplied was temporarily furnished with service from the Washington Heights pumping station, and since the abandonment of the latter has been supplied by the Roseland station.

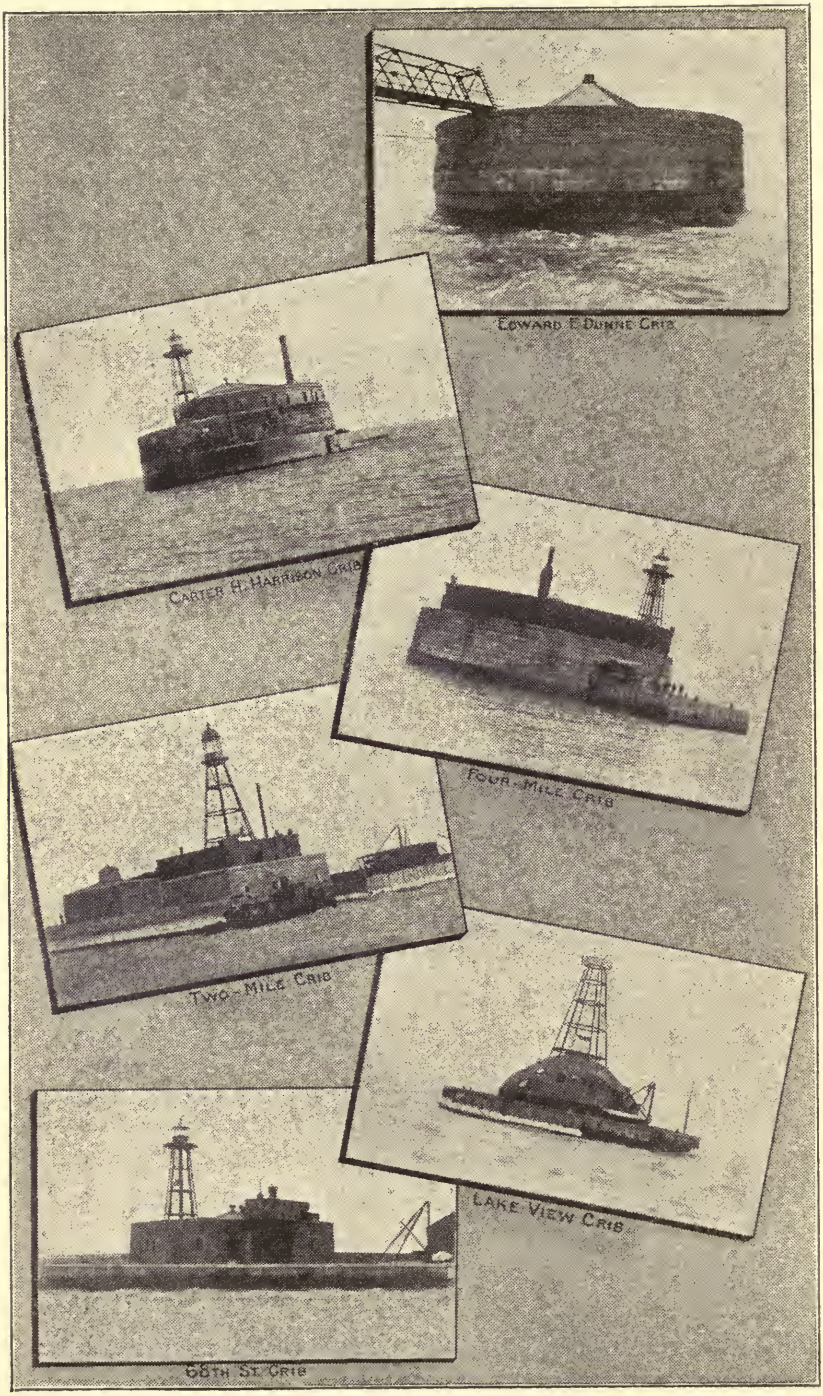
TUNNELS AND CRIBS

First Water Tunnel

Soon after the Chicago Avenue station was first operated in 1853, the problem of supplying not only a greater quantity but a better quality of water became urgent. To meet the situation, it was finally decided to construct a five-foot circular tunnel under the lake, extending in a northeasterly direction from a point near the Chicago Avenue station to an intake crib, since known as the Two-Mile crib, located about two miles offshore. The work was undertaken in 1864. The tunnel was completed and put into service in March, 1867. It has supplied water for the pumps at the Chicago Avenue station continuously since that date and is still in service.

Cross-Town and Blue Island Avenue Tunnels

To supply water for the pumps at the Twenty-second Street station, a second tunnel was constructed in 1874. It extended from the Two-Mile crib to the shore near the Chicago Avenue station and thence directly southwest



INTAKE CRIBS

across the City to the Twenty-second Street station. Hence it is known as the "Cross-Town Tunnel." It was constructed largely under private property and was later found to be an obstruction to deep building foundations. For that reason it became necessary to abandon the land portion of it lying southwest of the Chicago Avenue station.

The Blue Island Avenue tunnel, which is located entirely under streets, was accordingly constructed to supply the Twenty-second Street station. It was put into operation in 1909. It draws its supply of water from the Two-Mile crib through the lake section of the old Cross-Town tunnel, with which its eastern terminus in Delaware Place was connected in 1913.

North Shore Extension Tunnel

In 1887 the first section of the third or North Shore Extension tunnel was constructed. It is located just north of the original five-foot tunnel and at first extended only 1,500 feet under the lake, the land end being connected with the tunnel system of the Chicago Avenue station. It was designed for use when the supply at the Two-Mile crib was endangered by ice or otherwise.

The contamination of the water at the intake shaft of the new tunnel was such, however, that it proved practically useless and in 1891 it was extended to the north end of the Government breakwater. The water at this latter point was also found to be so badly contaminated that the tunnel was of little service, and in 1896 it was further extended to the Two-Mile crib.

Four-Mile and Polk Street Tunnels

By 1886 the capacity of the three tunnels previously constructed to supply the Chicago Avenue and Twenty-

second Street stations had been reached. A new system of tunnels, known as the Four-Mile and Polk Street tunnels, was therefore constructed to supply the pumps of the Harrison Street and Fourteenth Street stations then about to be built. The lake section of this new system extends from a point on the shore near Twelfth Street east four miles to the Four-Mile crib. One branch of the land section extends south to the Fourteenth Street station. Another branch extends north to Eighth Street and as originally constructed extended thence directly northwest to Desplaines Street and from there to the Harrison Street station. Like the Cross-Town tunnel, this "old Polk Street" tunnel was located largely under private property and was later found to interfere with deep building foundations. Accordingly, a new Polk Street tunnel which follows the street lines was constructed in 1907, after which the portion of the old tunnel between Eighth Street and Jefferson Street was abandoned. The new tunnel is interconnected with the Blue Island Avenue tunnel by a tunnel in Jefferson and Van Buren Streets.

Lake View Tunnel

At the time of its annexation in 1889, Lake View had commenced the construction of a lake tunnel which was subsequently completed by the City. It is six feet in diameter and extends from the Lake View station eastward about two miles to the Lake View crib. It is planned to connect this tunnel with the Wilson Avenue tunnel now under construction. When this connection has been made the Lake View crib will be abandoned and the water for both tunnels will be drawn through the intakes of the new Wilson Avenue crib.

Sixty-eighth Street Tunnels

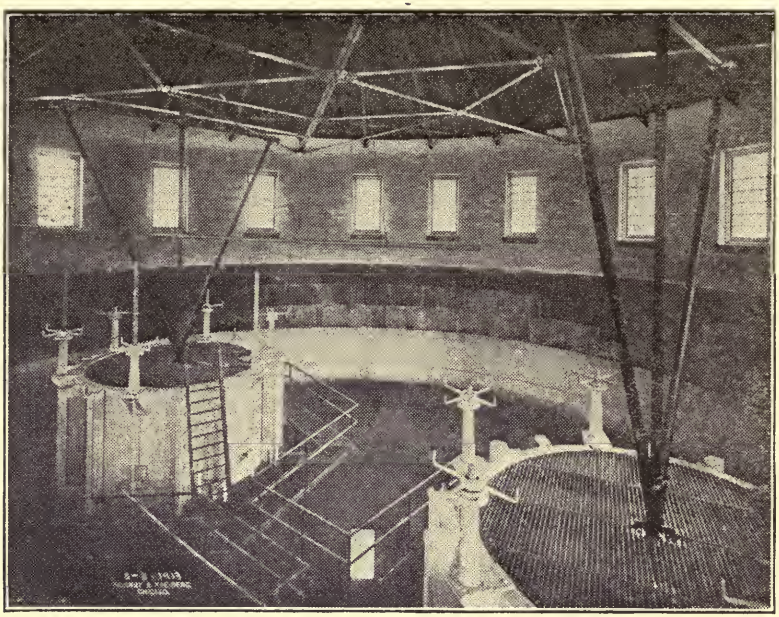
In 1884-85 the Village of Hyde Park had constructed a tunnel six feet in diameter, extending out into the lake about 5,000 feet. This tunnel was taken over by the City at the time of annexation. Subsequently a five-foot tunnel was constructed to the south of the old tunnel extending out under the lake a distance of about a mile, from which point a seven-foot tunnel was constructed out another mile terminating at the present Sixty-eighth Street crib. This new tunnel was completed in 1894. Beginning in 1896 a tunnel seven feet in diameter was constructed to the north of the old six-foot tunnel from a point near the shore to the point of connection between the five-foot and seven-foot tunnels completed in 1894. This new seven-foot tunnel was completed during the summer of 1898. The old six-foot tunnel was then abandoned and has not since been in use.

Northwest Land and Lake Tunnel

The Northwest Land and Lake tunnel system was completed in 1900. It was constructed to supply the pumps at the Central Park Avenue and Springfield Avenue stations. The main section which is ten feet in diameter extends from the Carter H. Harrison crib, located approximately three miles east of the lake shore at North Avenue, southwest to Green Street and Grand Avenue. From this latter point one branch eight feet in diameter extends southwest to the Central Park Avenue station; the other branch also eight feet in diameter extends northwest to the Springfield Avenue station.

Southwest Land Tunnel

The Southwest Land and Lake tunnel which was completed in 1911 has a capacity of 400,000,000 gallons and



EDWARD F. DUNNE CRIB

Interior view showing the crib well and the two intake shafts through which the water flows to the Southwest Land and Lake tunnel, 146 feet below.

Description of An Intake Crib

A crib is a timber or steel structure, usually a hollow cylinder in form, which is placed upon the bed of the lake and extends upward to above the water line. The space between the external and internal walls is usually filled with stone or concrete which holds the structure in place upon the bed of the lake. The area enclosed by the structure is known as the crib well. The purpose of the crib is to protect the vertical shaft or shafts which are located within the crib well and extend downward to the tunnel beneath the bed of the lake. The water enters the crib well through portholes in the side of the structure, and flows thence through the vertical intake shafts and the tunnel to the pumping station. The crib well is covered over and protected by a superstructure which usually contains living quarters for the crib keepers. (See diagram, page 33.)

The external diameter of the Edward F. Dunne crib which is sunk in 32 feet of water is 110 feet at the water line; the distance between the external and internal walls of the structure is 25 feet. The crib well is 60 feet in diameter. The two intake shafts are each 14 feet in diameter. No quarters for the crib keepers are provided on this crib which is located 45 feet south of the Sixty-eighth Street crib to which it is connected by a bridge for maintenance purposes.

was designed to supply the Roseland pumping station and also two other stations; one, the station now under consideration, to be located near Sixty-first Street and Western Avenue; the other, contemplated at some future time, to be located near One Hundred and Twenty-sixth Street and Yates Avenue. A connection with the Sixty-eighth Street station was also provided for and was completed in 1916.

This tunnel terminates at the Edward F. Dunne crib, located immediately south of the Sixty-eighth Street crib, to which it is connected by a bridge for maintenance purposes. From the crib the lake section which is fourteen feet in diameter extends southwest to Seventy-third Street and Yates Avenue; thence a twelve-foot branch extends west in Seventy-third Street to State Street. From Seventy-third and State Streets a nine-foot branch extends south to the Roseland station. Stub tunnels were also constructed in Yates Avenue at Seventy-third Street and in Seventy-third Street at State Street for use in connection with future extensions.

FURTHER IMPROVEMENTS PROPOSED OR UNDER CONSTRUCTION

Definite plans for further extensions of the present system within the next few years include the completion of the Wilson Avenue tunnel and the Mayfair pumping station, which are now under construction; an extension of the Southwest Land tunnel to a new station to be located near Sixty-first Street and Western Avenue; the replacement of the present Sixty-eighth Street station with a new station at Seventy-third Street and Stony Island Avenue; and the replacement of the two 1887 pumps at the Chicago Avenue station and of the four old

pumps at the Twenty-second Street station with modern centrifugal pumps.

In a paper read recently before the American Association of Engineers, Mr. John Ericson, the City Engineer, expressed the opinion that, in addition to the improvements above mentioned and in addition also to more and greater water mains, it will be necessary within the next twenty years (1) to build four other major pumping stations with tunnels to supply them; (2) to increase the daily capacities of the present Chicago Avenue, Harrison Street, and Central Park Avenue stations 50,000,000 gallons each; and (3) to construct a tunnel in the vicinity of Twelfth Street to reinforce the existing tunnel system.

The improvements mentioned in the last two paragraphs if carried out will practically double the capacity of the present plant.

Mayfair Station and Wilson Avenue Tunnel

The Mayfair station and Wilson Avenue tunnel which are now under construction will supply the northwestern section of the City. The station, which is located at Wilson and North Lamon Avenues, is designed for an ultimate capacity of 152,500,000 gallons per day. Four pumps will have a capacity of 25,000,000 gallons each and three pumps a capacity of 17,500,000 gallons each. The latter will be high pressure pumps and will supply the high level district now supplied by the Jefferson Park booster station. Three of the larger pumps and two of the high pressure pumps are now under construction and will probably be placed in service early in 1918, thus adding 110,000,000 gallons per day to the capacity of the plant. The remaining two pumps will be added to the equipment when an increased demand for water makes them necessary.

The Wilson Avenue tunnel which will supply this sta-

tion extends from the new Wilson Avenue crib, located about three miles off the lake shore, directly west under the line of Wilson Avenue to the station. It will have a normal capacity of 350,000,000 gallons per day. Its total length is approximately eight miles. From the crib west for a distance of about one mile the diameter of the tunnel is thirteen feet; beyond this point the diameter is twelve feet. The entire excavation is in solid rock.

The thirteen-foot section is to be connected with the present Lake View tunnel at the Lake View crib after which the use of this crib will be discontinued. A connecting tunnel has also been constructed under Clarendon Avenue from Wilson Avenue to the Lake View station. When put into service, this connecting tunnel will reinforce the supply from the present Lake View tunnel which is inadequate for all the pumps at the Lake View station.

III. WATER WORKS FINANCES

THE VALUE OF THE WATER WORKS PLANT

The aggregate original cost of the component parts of the water works plant December 31, 1916, as reported by the Department of Public Works, was $70,773,556. The reported value as distinguished from the reported cost was $60,550,503. This value is based upon certain allowances for appreciation on real estate and upon certain deductions for estimated depreciation on equipment, including deductions on account of equipment removed from service.

The actual value of the City's investment, if account be taken of the cost of reproducing the plant under conditions such as existed just prior to the war, and of the

numerous items which are properly a part of the cost of the plant as a whole but which are not included in the reported figures, is probably somewhat greater than either of the above amounts. Mr. John W. Alvord estimates this actual value at not far from $85,000,000.

The cost of the plant has been increasing rapidly during recent years. At the close of 1901 after the water works had been in operation 50 years the original cost amounted to about $34,000,000. At the close of 1916 it was about $70,000,000. Four-fifths of this increase has occurred within the last decade, and, as hereafter explained, is due largely to the efforts of City officials to cope with the waste problem by constantly providing additional pumps and other equipment.

The following table shows the amounts invested in the water works plant from year to year during the past 15 years; also the aggregate original cost of the plant at the close of each year.

Table Showing the Annual Investments in the Plant of the Chicago Water Works and the Aggregate Original Cost of the Plant at the Close of Each Year for the Period 1902 to 1916

Year	*Annual Investment*	*Original Cost at Close of Year*
1902	$1,626,873	$35,687,949
1903	1,666,974	37,354,923
1904	1,387,111	38,742,034
1905	357,222	39,099,256
1906	3,060,187	42,159,443
1907	3,839,640	45,999,083
1908	3,447,697	49,446,780
1909	1,769,922	51,216,702
1910	1,284,241	52,500,943
1911	1,816,976	54,317,919
1912	2,454,512	56,772,431
1913	2,248,040	59,020,471
1914	2,655,564	61,676,035
1915	4,811,405	66,487,440
1916	4,286,116	70,773,556

HOW THE COST OF THE PLANT HAS BEEN FINANCED

The total cost of the plant, aggregating $70,773,556.12 at the close of 1916, has been paid as follows:*

Water Revenue—	
From the revenue of the water fund directly	$51,748,252.11
From the proceeds of water certificates, subsequently redeemed from water revenue	7,916,000.00
From the proceeds of bonds, subsequently redeemed from water revenue	3,447,900.00
General Taxes—	
From general taxes directly	2,713,878.53
From the proceeds of bonds, subsequently redeemed by levying general taxes	2,628,400.00
Proceeds of Bonds Still Outstanding—	
From the proceeds of general corporate bonds issued in 1908	851,200.00
From the proceeds of water loan bonds (refunded in 1915)	1,270,400.00
Paid by communities subsequently annexed to the city	197,525.48
Total	$70,773,556.12

The item of $2,713,878.53 shown above was expended from general taxes early in the development of the property. No general taxes have been used directly for water works purposes for many years. Likewise, many years ago $5,000 raised by general taxation was applied to the redemption of water loan bonds. Except for these two items, prior to 1907 the plant was financed entirely from water revenue and from the proceeds of water loan bonds and water certificates which, so far as they had matured at that date, had been redeemed from water revenue.

*Compiled from the published reports of the Department of Public Works.

Since the close of 1906, however, a different policy has prevailed as to bond redemptions. Except for $225,000 paid from revenue in 1909, and $500,000 paid from the same source in 1913 to redeem a short-time issue for that amount which had been put out in 1910, all bond redemptions since 1906 have been made by levying a direct general property tax for that purpose. The sum of $2,623,400 has been thus raised and applied during the past ten years. At the close of 1916, there were still outstanding bonds amounting to $2,121,600, the proceeds of which had been used for water works purposes and which under the policy now prevailing are being redeemed from year to year with general tax moneys.

Interest on these bonds is also being paid out of general taxes. Prior to 1913, all payments of interest were made from the water fund, but since that time such payments have been made from taxes. During the four years ended December 31, 1916, general taxes amounting to $355,896 were levied and applied to the payment of bond interest.

Water works bonds, like other municipal bonds, create a liability against the City which must be met by general taxation unless the City Council makes provision for their payment from water revenue. Taxes for the payment of both principal and interest on such bonds are not included within the limitations placed by law upon tax levies for general corporate purposes, but must be levied in addition to all other taxes. Levying taxes for the payment of bond principal and interest, therefore, produces more revenue for water works purposes without curtailing in any way the City's revenue for other purposes, and without giving rise to the embarrassments which would attend an increase in water rates. This policy might be defended if the water fund were being used

only for water purposes and were inadequate for those purposes and could not be increased without real and valid objections. Such, however, is not the case. Moreover, levying taxes for the payment of bond principal and interest affords an easy way to relieve the water fund of its legitimate obligations and thus to make it possible for the City Council to divert water revenue to other uses. In recent years there has been a marked increase in the tendency to use the water fund for other purposes, notwithstanding the questionable legality of some of the expenditures made. Diverting the water fund to general corporate purposes and then levying a tax with which to pay water works obligations is an indirect way of levying additional taxes for general corporate purposes, a thing which under existing laws could not be done directly. This practice deserves severe condemnation.

The occasion for resorting to general taxation to redeem water works bonds results in part from this practice of diverting water revenue to other uses and in part from the enormous expenditures which have been made for additional equipment needed to meet the constantly increasing demand for more water due to waste and leakage.

THE FINANCIAL STATUS OF THE WATER WORKS BUSINESS

The financial status of the water works business as shown by the revenue, expenditures, and capital investment for the past three years, is substantially as follows:*

	1914	1915	1916
Revenue Received (see table 1, p. 71.).	$6,835,000	$6,448,000†	$6,796,000
Ordinary Operation and Maintenance (excludes interest on bonds; includes refunds) (see table 2, p. 72.).....	$3,218,000	$3,312,000	$3,555,000
Annual Depreciation on Plant and Property Taken Ordinarily in Water Works @ 1%.....	610,000	660,000	700,000
Total Operation and Maintenance....	$3,828,000	$3,972,000	$4,255,000
Excess of Revenue over Expense....	$3,007,000	$2,476,000	$2,541,000
Original Investment at Close of Year.	$61,000,000	$66,000,000	$70,000,000
Rate of Interest Return on Original Investment = Excess of Revenue / Original Investment	.0493	.0375	.0363

No revenue is derived directly from the City and other public agencies using water for fire protection and other public purposes. It might appear, therefore, that in the foregoing table a credit should be allowed for such service in addition to the revenue there shown. Of course, the cost of such service must necessarily be paid in some way and is, in fact, included in the charges made to private consumers and is collected from them. Accordingly, no further credit is shown in the table.

Likewise, no charge has been included in the table for taxes on the water works property. For the purposes of this report, the inclusion of such a charge would have no

* Compiled from figures published in annual reports of Department of Public Works.
† Decrease due to reduction in rates (see pp.66-7.)

real significance. Roughly estimated, the value of the water used for public purposes and the taxes with which the plant would be chargeable are about the same. Under these circumstances, if a charge for taxes were in fact made, as it would be if the property were privately owned, the public that received the taxes might be expected to pay an equivalent amount in water rates. This operation would not affect the actual financial status of either the water works business or the public. The transactions indicated, if carried out, would add the amount of taxes paid to the operating expenses and would also add a like amount to the revenue received. This would not change the interest return on the capital investment which is the significant figure in the table.

The surplus earnings (excess of revenue over expense) represent the return on the public's invested capital. To a considerable extent the public could profit by this return through lower water rates were it not for the fact, as will be seen by reference to the table on page 72, that it is being continually reinvested in extensions of the plant. Many of these extensions would not be necessary but for the large amount of waste and leakage which prevail. Thus waste and leakage are depriving the community of a substantial part of the benefit which it should obtain through its ownership of the water works system.

WATER RATES

Chicago sells water upon the so-called "frontage" or "assessed rates" plan, and also upon the meter plan. Where the assessment plan is used for fixing rates the basic charge depends upon the width and height of the building. Additional charges, which vary with the width of the lot, the purpose for which the building is used, the number of fixtures therein, and other conditions, are also

made. Where premises are used for residence purposes only, there is no charge in addition to the basic charge for the first complete set of sanitary fixtures.

Except as indicated in the next paragraph, the assessed rates are applicable as a basis for determining charges in all cases where the net assessment (after deducting the discount of 25 per cent allowed for prompt payment) is less than $30.00 a year. At the close of 1916 approximately 280,000 consumers, or 93 per cent of the total number, were furnished water on the assessed rates basis.

The meter rate is 62½ cents per thousand cubic feet, subject to a discount of 25 per cent for prompt payment, or approximately 6¼ cents net per thousand gallons. There is no minimum charge for service, each consumer paying only for as much water as he may take. The meter rate applies to all premises where the net charges on the assessed rates basis would aggregate $30.00 or more a year; also to all premises used for certain industrial and commercial purposes and to certain other special classes of occupancy without regard to the quantity of water used.* At the close of 1916 approximately 21,000 consumers, or 7 per cent of the total number, paid on the meter basis for the water which they took.

But few consumers fail to take advantage of the discount allowed for prompt payment. In practically all cases, therefore, raising the discount rate operates to decrease water bills; lowering the discount rate operates to increase bills.

November 1, 1914—on the eve of the mayoralty election

*An ordinance passed by the City Council on June 25, 1917, reduced the maximum assessed rate charge from $100 to $30 a year net, and also extended the meter service to certain types of premises which theretofore had not been placed on the meter basis. On December 1, 1917, the number of unmetered consumers was approximately 285,000; the number of metered consumers, about 22,000.

of 1915—the discount rate was raised from 15 to 25 per cent. This change in discount operated to reduce consumers' bills and was heralded as an achievement of the administration then in office. The change also operated to reduce the revenue of the water fund by more than $800,000 annually.

At the time this change was made the surplus in the water fund was approximately $4,160,000. This large surplus had resulted in part from the sale of general corporate bonds in 1908, $1,008,000 of which were still outstanding, and in part from the failure to redeem water loan bonds as they matured and to pay the interest thereon with water revenue. Up to the close of 1914, approximately $2,485,000 in general taxes had been levied and paid out on account of the principal and interest of water works bonds. Thus practically the entire surplus in the water fund at that time had been built up either by selling bonds or by meeting bond payments with general tax funds instead of with water revenue. In addition to this, at the time the change in the discount rate was made large capital outlays for plant extensions were either under way or in contemplation as a result of the efforts being made to meet the increasing and excessive demand for water due to waste and leakage. Further, a large amount of water fund revenue was being used for general corporate purposes.

In view of this whole situation, the wisdom and expediency of such a reduction in water fund revenue were to be seriously questioned. The crippling of the fund might have been anticipated, particularly since no steps were taken to check the drain upon it for plant extensions and for general corporate purposes. As a matter of fact, since 1914 expenditures have far exceeded revenue, and the surplus which at that time was more than $4,000,000 has become so seriously impaired that water cer-

tificates to the amount of $500,000 have been issued during the current year, and a further loan of $500,000 has been authorized and probably will soon be necessary. The Finance Committee of the City Council has also recommended raising water rates to a higher level than obtained prior to the reduction of 1914. The Council defeated the proposed increase in rates, but such an increase will probably soon become unavoidable unless expenditures are curbed.

FREE WATER

Besides the water which is sold, a large amount of water is furnished free of charge. In general, this free service includes all water used for public purposes, including that used in the extinguishment of fires, in the cleaning and sprinkling of streets, in the flushing of sewers, in street improvement work, and for park purposes; also a large amount used by private institutions of a religious, educational, or charitable nature. It is furnished to all city buildings, departments and institutions; to the county and other public hospitals; to the public library and its branches; to the municipal tuberculosis sanitarium and dispensaries; to state hospitals, asylums, schools and armories; to the various park boards for all park purposes; and to numerous churches, parsonages, convents, private and parochial schools, private hospitals, and other charitable and educational institutions.

The value of the free service furnished to buildings, as distinguished from that furnished for outside purposes, in 1916 aggregated $328,918, on the basis of the usual charges made for similar service furnished to ordinary private consumers. Since but few of these premises are

provided with meters, there are no reliable data as to how much water they actually used or wasted. The above amount does not include any allowance for water used outside of buildings such as that used for extinguishing fires, sprinkling and cleaning streets, flushing sewers and other similar uses, or for water used for general park purposes. The value of this outside service, which can only be approximated, probably amounts to about $1,000,000 per year. The cost of all such service, which is ordinarily spoken of as being free, of course has to be paid and is in fact included in the charges collected from the revenue paying consumers.

Of the free service furnished to buildings, slightly less than 40 per cent goes to private institutions, many of which not only receive water free but have their service pipes installed free of charge by the City. The expense of such work is ordinarily borne by the consumer.

The extent to which water used for public or quasi-public purposes shall be charged for, and the charges collected and paid into the water fund, involves largely questions of public policy. The practice varies widely in different cities. Some cities insist upon all municipal departments as well as all other governmental agencies and all charitable, religious, and educational institutions paying for the water which they take. Others exempt all such users from payment, requiring the water works to furnish the service free. Between these two extremes there are many variations of policy. There are but few cities, however, which are as liberal as Chicago is with its free service.

The way in which the questions of policy involved in this matter are determined is of less importance than the adoption of effective measures to prevent waste and leakage on the premises of such consumers. At present

less than 10 per cent of them are under meter control, and even where meters have been installed no limitation is placed upon the amount of water that may be taken free of charge. Under such conditions it is inevitable that there will be a large amount of waste and leakage in connection with this free service.

As a waste prevention measure, the Bureau recommends that so far as practicable all free service whether furnished for public uses or to private institutions be placed under meter control at once; that the maximum amount of water to be provided free in each instance be fixed, such maximum to be determined by the legitimate requirements of the user; and that all city departments, other governing agencies, and private institutions receiving such free service be required to pay at the regular meter rate for all the water passing through the meters in excess of the maximum amount thus established.

REVENUE AND EXPENDITURES

The following tables show the annual revenue received by the water fund and the expenditures made therefrom for the five-year period ended December 31, 1916; also the surplus to the credit of the fund at the close of each year. Tables 4, 5, and 6 show in more detail the expenditures set forth in table 2.

TABLE 1.

Table Showing Revenue Received by the Water Fund for the Five-Year Period Ended December 31, 1916

	1912	1913	1914	1915	1916
Assessed Rates Charges	$3,327,574.16	$3,467,676.03	$3,392,674.39	$3,376,350.57	$3,446,490.69
Meter Rates Charges	2,877,379.90	3,028,232.72	3,020,437.88	2,761,367.60	3,081,158.08
Miscellaneous	325,103.17	318,065.08	422,503.30	310,528.87	268,997.62
Total	$6,530,057.23	$6,813,973.83	$6,835,615.57	$6,448,247.04	$6,796,646.39

TABLE 2.

Table Showing Expenditures from the Water Fund for the Five-Year Period Ended December 31, 1916

	1912	1913	1914	1915	1916
Operation	$2,224,602.68	$1,993,577.82	$1,750,332.53	$1,842,046.07	$2,277,275.19
Repairs and Renewals (Ordinary Maintenance)	1,364,037.72	1,325,103.90	1,443,549.22	1,445,502.11	1,252,753.05
Additions, Extensions and Betterments.	2,456,841.57	2,210,860.91	2,727,108.88	4,811,405.42	4,286,115.56
Miscellaneous (Transfers to Capital Accounts Excluded)	628,281.87*(a)	597,881.13*(b)	105,789.97*	154,608.30*	68,683.85*
Total	$6,673,763.84	$6,127,423.76	$6,026,780.60	$8,253,561.90	$7,884,827.65

NOTE—Each annual report of the Department of Public Works contains two sets of statements covering "expenditures" from the water fund. One of these sets includes all charges made against appropriations during the current year, such charges being classified as "ordinary" and "extraordinary." These figures agree with the appropriation expenditures reported by the City Comptroller. The expenditures shown by the other statements are classified as to "operation," "repairs and renewals" (ordinary maintenance), and "additions, extensions, and betterments." The appropriation expenditures exceed those included in the other classification. This is due partly to the inclusion in the former of payments made in liquidation of deferred liabilities, refunds, etc., which are omitted from the latter. Apparently also a slightly different basis is used in preparing the different statements. It is impossible to reconcile the differences which appear and to distribute the excesses shown by the appropriation accounts without a detailed examination of all the vouchers involved. In the table here shown the figures appearing in the second set of statements have been used in each instance. In order to show the total expenditures for each year there has also been included in the table a balancing figure designated "miscellaneous" which covers the undistributed excess of expenditures shown by the appropriation statements. Apparently the principal items included in this classification are refunds and the redemption of bonds, water certificates and water pipe extension certificates.

* Includes refunds as follows: 1912, $20,358.62; 1913, $25,264.07; 1914, $24,987.84; 1915, $25,019.84; 1916, $24,999.70.

(a) Includes $500,000 for redemption of water certificates.

(b) Includes $500,000 for redemption of water loan bonds.

TABLE 3.

Table Showing Revenue, Expenditures, and Surplus of the Water Fund for the Five-Year Period Ended December 31, 1916

	Revenue	Expenditures	Surplus at Close of the Year
1911	.....	.....	$2,444,873.28
1912	$6,530,057.23	$6,673,763.84	2,281,451.71
1913	6,813,973.83	6,127,423.76	3,249,802.44
1914	6,835,615.57	6,026,780.60	4,160,018.06
1915	6,448,247.04	8,253,561.90	2,629,759.98
1916	6,796,646.39	7,884,827.65	1,281,908.54

NOTE—Sundry credits and charges in the surplus account, which result principally from capital account transactions and are not included in the revenue and expenditure accounts, are not shown in detail in the table.

TABLE 4.

Table Showing Operating Expenditures for the Five-Year Period Ended December 31, 1916

	1912	1913	1914	1915	1916	Total 5-Year Period
General Superintendence	$38,915.18	$45,330.64	$27,645.89	$29,380.55	$26,562.97	$167,835.23
Engineering Division	34,795.53	29,748.28	35,889.54	38,879.35	37,034.51	176,347.21
Testing Division	24,098.14	22,414.87	33,357.27	50.92	.....	79,921.20
Superintendence of Pumping Stations, Cribs and Repair Shops	22,237.05	17,632.10	14,019.89	16,923.79	16,491.30	87,304.13
Cribs	43,729.20	42,427.98	45,661.31	46,111.99	44,127.49	222,057.97
Tug Service (to Cribs)	11,736.26	11,115.55	11,187.11	9,635.42	6,125.85	49,800.19
Water Pumping Stations	941,360.48	902,832.57	991,255.53	995,471.53	948,156.95	4,779,077.06
Fullerton Ave. Sewage Pumping Station	8,063.45	2,419.04	1,998.75	1,808.11	1,343.87	15,633.22
Other Sewage Pumping Stations	.....	.....	.....	72,111.20	66,046.81	138,158.01
Assessment and Collection of Water Rates	329,724.88	299,900.84	320,773.43	339,474.29	353,528.62	1,643,402.06
Services of Other City Departments	421,420.03	452,860.14	249,327.29	278,356.11	753,642.65	2,155,606.22
Miscellaneous	348,522.48	166,895.81	19,216.52	13,842.81	24,214.17	572,691.79
Total	$2,224,602.68	$1,993,577.82	$1,750,332.53	$1,842,046.07	$2,277,275.19	$10,087,834.29

TABLE 5.

Table Showing Expenditures for Repairs and Renewals of Water Works Property and Equipment for the Five-Year Period Ended December 31, 1916

	1912	1913	1914	1915	1916	Total 5-Year Period
Cribs	$13,409.78	$12,360.31	$14,734.61	$8,583.67	$13,979.26	$63,067.63
Tunnels	3,380.44	9,697.10	5,301.24	23,297.06	12,947.47	54,623.31
Water Pumping Stations	260,985.20	224,770.47	228,664.67	175,002.62	195,631.12	1,085,054.08
Fullerton Ave. Sewage Pumping Station	470.48	492.45	219.51	15.95	26.10	1,224.49
Other Sewage Pumping Stations	.....	.....	.....	4,659.17	6,062.15	10,721.32
Mains, Hydrants, and Valves	843,933.03	854,630.87	1,067,160.51	1,107,173.97	905,094.41	4,777,992.79
Tapping and Retapping (mains)	79,995.47	80,354.50	57,625.73	60,455.34	51,026.49	329,457.53
Service Pipes, Shut-off Boxes, etc.	72,188.29	60,685.00	.....	.....	.....	132,873.29
Meters	72,168.53	68,105.20	67,924.30	64,008.15	65,729.71	337,935.89
Miscellaneous	17,506.50	14,008.00	1,918.65	2,306.18	2,256.34	37,995.67
Total	$1,364,037.72	$1,325,103.90	$1,443,549.22	$1,445,502.11	$1,252,753.05	$6,830,946.00

TABLE 6.

Table Showing Expenditures for Additions, Extensions, and Betterments of Water Works Property and Equipment for the Five-Year Period Ended December 31, 1916

	1912	1913	1914	1915	1916	Total 5- Year Period
Tunnels and Cribs	$92,262.17	$265,569.06	$274,721.76	$1,260,115.17	$1,116,540.22	$3,009,208.38
Water Pumping Stations	506,072.91	482,050.81	629,921.74	577,956.70	836,781.10	3,032,783.26
Fullerton Ave. Sewage Pumping Station and Intake Crib	6,672.31	14,298.19	2,740.35	.....	.....	23,710.85
Other Sewage Pumping Stations	.....	.....	.....	9,303.05	10,470.79	19,773.84
Mains, Hydrants, and Valves	1,719,222.00	1,173,945.00	1,462,354.31	2,052,469.58	1,590,963.51	7,998,954.40
Pipe Yards	1,512.44	2,836.68	4,743.14	3,442.24	8,533.08	21,067.58
Municipal Repair Shops and Plant	12,667.03	39,486.40	279,051.97	692,416.49	604,696.13	1,628,318.02
Meters	53,258.89	42,103.01	56,937.67	136,897.82	58,518.91	347,716.30
Natatoriums and Swimming Pools	9,750.50	.....	4,702.78	72,529.21	32,406.37	119,388.86
Purchase of Real Estate	.....	188,107.48	6,682.94	.....	25,000.00	219,790.42
Miscellaneous	55,423.32	2,464.28	5,252.22	6,275.16	2,205.45	71,620.43
Total	$2,456,841.57	$2,210,860.91	$2,727,108.88	$4,811,405.42	$4,286,115.56	$16,492,332.34

At the close of 1916 there were 20,768 meter accounts and 279,109 assessed rates accounts on the books of the Bureau of Water. Thus 6.9 per cent of the premises supplied were metered and 93.1 per cent were unmetered.

The meters in service at the close of 1916 were distributed as follows:

Stores and flats	4,259
Business houses	1,791
Residence and apartment buildings	6,188
Factories	3,229
Railroads	795
Breweries	185
Liveries	634
Packing houses	176
Laundries	596
Hotels	373
Office buildings	414
Theaters	114
Charitable institutions	80
Miscellaneous	1,934
Total	20,768

It will be noted from the table on page 71 that these metered consumers paid a little less than half (47 per cent in 1916) of the revenue derived from the sale of water. They took (including a 5 per cent allowance for meter slippage)a little less than one-fourth (22 per cent) of the total amount of water pumped.* Since the water thus taken was paid for on a measured service basis, presumably use was made of the greater part of it and only a comparatively small part was wasted. Approximately 600 of the larger consumers, among which are the railroads, packing houses, factories, hotels, breweries, and

*The gross pumpage in 1916 was 236,139,380,000 gallons; the metered consumption, including that supplied to outside communities, was 50,541,560,000 gallons.

commercial and office buildings, take about half of the metered supply.

The unmetered consumers on the other hand paid slightly more than half (53 per cent) of the revenue received and apparently *used* slightly less than one-sixth (15 per cent) of the water pumped. "Used" in this connection is employed in contradistinction to "lost through waste and leakage" and is meant to include only water consumed for purposes for which water is necessary or has any real value.

Of the remaining 63 per cent of the water pumped, probably about 3 per cent was *used* for public purposes and 60 per cent was *lost through waste and leakage.* How much of this loss occurred in the delivery of the water to consumers and how much of it occurred after the water reached their premises is not known. Two-thirds of it probably occurred after such delivery.

The consumers who pay for their water by meter pay 6¼ cents per thousand gallons registered by the meters. Since some water slips through the meters without registering, the rate to these consumers for the water which they actually receive is less than 6¼ cents. Assuming a meter slippage of 5 per cent, they pay 5.9 cents per thousand gallons for their supply.

The unmetered consumers apparently *take* about 55 per cent of the pumpage. They *use* about 15 per cent, and they *throw away* through waste and leakage about 40 per cent, or more than two and a half times as much as they *use.* For that which they *used* they paid in 1916 at the rate of about 9.9 cents per thousand gallons, but for that which they *took,* including that which they threw away and which did no one any good, they paid only about 2.6 cents per thousand gallons. This was less than the cost of supplying the water, which in 1916, including fixed

charges (interest and depreciation), was about 2.9 cents per thousand gallons.

In a municipally owned and operated water works business the rate at which water is sold to revenue paying consumers is influenced by other considerations than the amount of money required for direct operating and maintenance charges. Among such considerations are the amounts required for sinking fund and construction purposes, and also the amount of water supplied for public purposes or lost in delivery and from which no revenue is derived. Such rates may therefore properly be higher or lower than the cost of the water supplied as above estimated upon the basis of operation and maintenance charges plus depreciation and interest. It must be apparent, however, that the unmetered consumers, by permitting the enormous waste and leakage which exist on their premises, are unnecessarily imposing a very large financial burden both upon themselves and the metered consumers.

It will be noted from table 3 (page 73) that recent expenditures have been exceeding revenue and that the surplus has been materially reduced. The actual condition of the water fund December 31, 1916, was worse than the surplus of $1,281,908 shown in the table would indicate. Of this amount, $1,225,373 had been set apart for working capital accounts, and was then tied up either in cash or in material. Thus the actual available cash balance in the fund at the beginning of 1917 was only $56,535. The appropriations for the current year exceed the estimated revenue by about $1,700,000. There may be a large salvage on these appropriations, but even taking that into account it is improbable that the actual expenditures will be kept within the revenue received.

Foreseeing this situation, the Finance Committee of

the City Council in June, 1917, authorized the borrowing of $1,000,000 on water certificates and recommended also a 20 per cent increase in water rates. The Council approved the first project. Five hundred thousand dollars has since been borrowed and at present the balance in the fund is such as to indicate that shortly it will be necessary to borrow the remaining $500,000 authorized. The proposal to raise rates was not adopted.

The present reduced condition of the water fund is due chiefly to the drain upon it for additional equipment necessary to meet the increasing demand for water due to waste and leakage.

WATER FUND DIVERTED TO CORPORATE USES

Another factor which has contributed to the financial situation above described is the use of large sums of water revenue for other than water works purposes. The water fund is being continually appropriated for other municipal projects and for the work of other departments of the City government. This practice is an old one but has been greatly extended within the past few years. It is objectionable on several grounds:

1. On principle, the revenue produced by a public utility like the water works should not be used for any purpose not properly related to the operation of the plant and to the extension and improvement of the service. When the revenue exceeds the amount required for such purposes the rates should be reduced. The water service should not become a means of raising revenue because use of water is not an indication of ability to pay taxes.

2. To sanction the practice is to invite extravagance and abuses. Other City departments should be required to operate on ordinary corporate revenues derived from

general taxation and miscellaneous sources. Whenever it appears that the general corporate revenues are insufficient to meet legitimate needs, that issue should be considered on its merits and appropriate direct relief afforded. Any other policy is wrong on general principles. But aside from that, the very fact that the surplus in a fund like the water fund may be diverted to the use of other City departments, when their legitimate revenue has been exhausted, is a constant temptation to wasteful expenditures by such departments. Besides, the danger of serious abuses developing is always present when the City authorities, if they yield to the very natural pressure which such a possibility produces, can create a surplus to be thus used by so simple a device as changing the discount rate on water bills (lowering the discount rate 10 per cent will increase the water revenue about $1,000,000 annually) or by invoking general tax levies to meet obligations which otherwise would have to be paid from the water fund. For instance, each year for several years past the tax levy for general corporate purposes has been in effect increased beyond the limit fixed by law by levying taxes for the redemption of water loan bonds and the payment of interest thereon—obligations which properly should be paid from the water fund—and by then, in turn, transferring large sums of water revenue to help out the other departments. The only way to avoid situations of this sort is to adhere strictly to the principle that water revenue is to be used only for purposes properly related to the water service.

3. The law provides expressly that the water fund shall be used only for water works purposes.

Notwithstanding both the impropriety and the illegality of diverting the fund to other purposes, it is being done continually. As has been said, the practice is an old

one, but reference to the methods employed in recent years will suffice to illustrate how it operates.

Generally, although not always, the appropriations are made on the theory that other City departments render service to the water works and that the cost of such service should be borne by the water fund.

In 1913, the property known as the Maxwell tract, located at Thirty-first Street and California Avenue, was purchased at a cost of approximately $195,000. The primary purpose of this purchase was to provide a site for the new municipal shops then in contemplation. Immediately, however, more than one-third of the entire tract was set apart as a site for the new contagious diseases hospital which has since been erected thereon.

In 1915, an appropriation of $30,000 was made for the purchase of a tug boat for service between the shore and the intake cribs. The plans for this purchase were afterward abandoned, and $4,500 of the appropriation was diverted to buying a gas power boat for which the water works officials have no use but which is being used by the harbormaster.

The sewer system is not so related to the water supply system as to make the cost of operating and maintaining it a proper charge upon the water fund. Notwithstanding this, in 1915, five sewage pumping stations, which had originally been constructed by special assessment and had for many years been operated with general corporate revenue, were added to the burden carried by the water fund. During 1915 and 1916 a total of approximately $160,000 was expended for their operation, maintenance, and betterment. The 1917 appropriations for the same purposes aggregate about $92,000.

In 1916, 86 per cent of the cost of operating and maintaining the Bureau of Sewers was also transferred to

the water fund. This expense had previously been borne, and properly so, by the corporate fund. This latest raid on the water revenue cost the water fund $411,280 in 1916, and will cost it approximately $360,000 in 1917.

For several years prior to 1916, the salaries of a number of dredging inspectors and harbor police were paid from water revenue. This expenditure is justified on the ground that it is necessary to protect the water supply from being polluted by scows and vessels dumping contaminating matter in the lake near the intake cribs. The aggregate amounts of the salaries paid ranged from $14,000 to $19,000 a year, depending upon the number of men employed. In 1916, the Bureau of Rivers and Harbors was organized and the dredging inspectors and harbor police were placed under its jurisdiction. When this new bureau submitted its budget request to the City Council it estimated that approximately 9 per cent of its total expenditures would be equivalent to the salaries to be paid the employes mentioned. Therefore, the Council was asked to direct that 9 per cent of the appropriation made for the new bureau be charged to the water fund. The Council acted in accordance with this request. Before making the appropriation, however, the Council itself, besides changing the estimates submitted by the bureau in some other respects, increased the salaries to be paid to bridge tenders, who are also under the jurisdiction of the Bureau of Rivers and Harbors. After such changes had been made 9 per cent of the total appropriation for the bureau no longer represented the value of the services to be furnished on account of the water supply. The figure of 9 per cent was permitted to stand, however. As a result of this maneuvering, the water fund contributed $27,618 instead of $16,500 (the amount specifically appropriated for salaries of inspectors and

police) or about $11,000 for which it apparently received little or no service. Substantially the same result will follow also in 1917.

There is much to be said in support of the theory that certain City departments render services on account of the water works business and that they should be paid therefor from the water fund. The different branches of the water works service occupy valuable space in the City Hall for which a rental charge is proper. Departments such as the Department of Finance, the Law Department, the Department of Supplies, and certain other departments also perform work which may properly be paid for from the water fund. In the application of this theory, however, much imposition has been practiced.

The method usually employed in such cases is to reimburse the corporate fund by charging the water fund with a certain percentage of the expense of the department or bureau rendering the service. Occasionally salaries and other expenses of such departments or bureaus are specifically appropriated for in the water fund budget. The following table shows the amounts thus expended from the water fund in 1915 and 1916 and the several departments or bureaus involved in the transactions; also what percentage of the total appropriation of each department or bureau was charged to the water fund.

Table Showing Amounts Expended from the Corporate Fund and Subsequently Charged to the Water Fund in 1915 and 1916; also the Departments and Bureaus Making Such Expenditures and the Percentage of the Total Expenditure of Each which Was Charged to the Water Fund*

	1915		1916	
	Amount	Per Cent	Amount	Per Cent
City Council	$20,887.65	10	$21,275.00	10
Committee on Finance	687.06	10	3,239.53	10
City Clerk	5,190.38	10†	5,028.61	10†
Corporation Counsel	37,248.71	16	41,426.09	16
City Attorney	28,103.32	21	28,371.09	21
City Comptroller	43,172.86	20†	38,244.11	20†
City Treasurer	12,321.34	20†	11,632.83	20†
Civil Service Commission	18,952.20	20	15,824.60	20
Department of Supplies	7,580.76	25	13,599.62	40
Board of Local Improvements	34,953.50	5†	35,753.36	5†
Department of Public Works (Commissioner's Office)	29,380.55	55	26,562.98	55
Bureau of Maps and Plats	4,344.15	10	4,188.54	10
Bureau of City Hall	19,561.17	8	59,962.15	25
Bureau of Sewers	.....	..	411,280.39	86
Bureau of Harbors	‡ 19,415.10	..	27,618.27	9
Department of Health (Laboratories)	‡ 5,481.69	..	7,411.70	20
Total	$287,280.44		$751,418.87	

* As reported by City Comptroller.

† Except certain specific items of the appropriation for such office.

‡ Appropriated directly from water fund; not a reimbursement.

The theory upon which charges of this kind are justified implies that the services rendered are necessary to the carrying on of the water works business. Obviously, such charges should be limited to services of that kind. Moreover, assuming the correctness of the theory, there should be some definite relation between the value of the services rendered and the amount charged. Unfortunately, in the past that has not been the case and there is no definite assurance that it is so even now. The situation resulting from the appropriation for the Bureau of Rivers and Harbors above referred to is typical. Often expenditures of this kind have been limited only by what

the traffic would decently bear. A comparison of the figures since 1910 as shown in the following table well illustrates this.

Table Showing Expenditures from the Water Fund to Cover Services Rendered by Other City Departments for the Period 1910 to 1916*

Year	*Amount*
1910	$277,097
1911	287,376
1912	438,349
1913	474,435
1914	254,008
1915	287,280
1916	751,419

The unusually large expenditures shown for 1912 and 1913 are accounted for by the fact that the City was short in its general corporate revenue because of a court decision which deprived it of about $3,000,000 in taxes. To help out the situation, appropriations from the water fund were increased to the extent indicated.

The 1916 figure includes the appropriation for the Bureau of Sewers already referred to.

Prior to the passage of the appropriation ordinance in 1914, the Commissioner of Public Works raised some question as to the propriety or legality of using the water fund for ordinary corporate purposes. Thereupon an ordinance was passed fixing the proportionate amounts of the expenditures of other departments which should

*The figures used in this table are those reported by the City Comptroller, the details of which for the years 1915 and 1916 are shown in the preceding table. These figures differ somewhat from those reported by the Commissioner of Public Works shown in Table 4, page 74. The reasons for such differences do not appear in the reports.

thereafter be charged to the water fund. This ordinance recites that the heads of the various branches of the City government rendering such services have made estimates of the amounts properly chargeable to the water fund, from which estimates the City Comptroller has arrived at the just and equitable percentage of the expenditures of each office that should be borne by that fund, but the Bureau has not been able to find the data or, in most cases, to ascertain the basis upon which the percentages then established and now in effect were determined.

The most flagrant violation of both the spirit and the letter of the law prohibiting the use of water revenue for other than water works purposes is to be found in the expenditures made in recent years on account of the sewage pumping stations and the Bureau of Sewers. Whatever might be said of the right to use the water fund to prevent sewage from polluting the water supply, the fact is that the expenditures now made from this fund are not for such purpose.

The sewage pumping stations are operated in connection with the sewer system in certain districts in the southern portion of the City. They were built by special assessment and prior to 1915 were operated and maintained with the corporate fund. These stations receive the sewage from the smaller sewers in their respective districts and pump it into larger conduits leading to the Calumet River, except in one instance where it is pumped into the Stony Island Avenue sewer. The sewage pumping stations are no part of the water supply system and have no connection with it. It is clearly improper that the water fund should carry the burden of operating and maintaining them.

The appropriations for the Bureau of Sewers, 86 per cent of which is being paid from the water fund, include

items for the general administration of the bureau, for cleaning and repairing sewers, for inspection service, and for the restoration of streets after openings have been made therein. Like the sewage pumping stations, the sewers are in no sense a part of the water supply system. The use of the water fund for this purpose, as well as for the sewage pumping stations, is plainly in violation of the law restricting the application of water revenue to water works purposes. The present practice could probably be stopped if a taxpayer were to institute legal proceedings. Such proceedings if undertaken might seriously embarrass the work of the Bureau of Sewers, and the City Council should itself correct the situation by hereafter appropriating exclusively from the corporate fund for the purposes mentioned.

The Chicago Bureau of Public Efficiency recommends that in the future appropriations from the water fund be limited to water works purposes, and that all other activities, including the operation of the sewage pumping stations and the work of the Bureau of Sewers, be carried on either with ordinary corporate or such other revenue as is properly applicable thereto. So far as the reimbursement of the corporate fund for expenditures made from it on account of the water works business is concerned, the charges made should represent the cost of the services rendered. Steps should be taken to establish definitely the value of such services and to place such transactions upon a businesslike basis.

IV. CHICAGO'S WATER SUPPLY PROBLEMS

The function of a properly constructed and operated water supply system is to furnish an *adequate supply* of *pure water* at a *reasonable cost.* The main problem in Chicago has been, and still is, to obtain water of a desirable degree of purity and also to keep pace with a constant demand for a greater quantity.

THE QUESTION OF COST

The Chicago Water Works is in the business of supplying the community with water. Because Lake Michigan furnishes an unlimited supply close at hand and the only expense involved in furnishing it to consumers is the cost of transporting it to their premises, the direct charges to water users are lower than in many other communities, but they are somewhat higher than in Cleveland and in Milwaukee where similar conditions of supply and requirements of distribution exist. Moreover, rates are higher in Chicago than would be required for much better service than is now furnished if it were not for the excessive amount of water lost through waste and leakage after the supply leaves the pumping stations.

THE PURITY OF THE SUPPLY

The Problem as Related to Health

From the standpoint of purity, "the water supply problem consists in securing such a quality of water as will satisfy the needs of the city so far as health is concerned and satisfy reasonable esthetic demands. Neither

of these can be neglected. The water must be wholesome and it must look so.''*

For Chicago, Lake Michigan furnishes an inexhaustible quantity of water of a high degree of original purity. That the City has always had trouble with the quality of its water supply has been due principally to the vast amount of human and industrial wastes which Chicago itself and the neighboring cities and towns have discharged into the lake. As related to health, therefore, the problem has been largely to avoid and to prevent this pollution. The increasing quantities of filth to be disposed of, as both Chicago and the neighboring territory along the shores of the lake have grown in population and in industrial importance, and the more exacting requirements demanded in recent years by higher standards of purity have added greatly to the difficulties of the problem. Within the past few years efforts to avoid and to prevent pollution have been supplemented by treating the water with chlorine as a means of further purification.

Efforts to Avoid Pollution by Constructing Cribs and Tunnels

The early settlers in Chicago took their water from wells and from the Chicago River. Later water was brought from the lake and peddled about the City in hogsheads mounted on wheels and drawn by horses. Beginning in 1842, the Chicago Hydraulic Company, a private corporation, supplied a small portion of the City with water by means of a pumping engine located at Lake Street and Michigan Avenue. The water was drawn through an intake pipe extending into the lake about 500 feet. It is said, however, that in 1853, when the City began to operate its own water works, about 80 per cent

*Report to The Chicago Real Estate Board on Water Supply and Sewage Disposal by Messrs. Soper, Watson, and Martin, 1915.

of the population then estimated at 65,000 still obtained its water from wells and water carts. The water obtained from all these earlier sources was frequently contaminated and was extremely unsatisfactory.

The City itself constructed its first pumping station at Chicago Avenue and the lake, and the water to supply the pumps was drawn from an inlet basin at the foot of Chicago Avenue, the basin being separated from the lake by a semi-circular breakwater with an opening to the southeast. The distance from this intake to the mouth of the Chicago River was about 3,000 feet. It was thought that water drawn through an inlet located at this distance from the mouth of the river would be free from contamination. However, the rapid growth of the City which followed soon after the opening of the Chicago Avenue station, the introduction of a sewerage system emptying into the river, and the establishment of the packing and other industries, resulting in the production of large quantities of industrial wastes, greatly increased the amount of filth discharged into the lake by way of the river, and this contamination, carried northward by the winds and lake currents, affected the water at the Chicago Avenue intake to such an extent that it soon became apparent that some other source of supply must be secured.

Accordingly, the Two-Mile crib was planned and constructed. The plan was to extend the intake out into the lake and to take the water farther from the source of pollution, the theory being that the polluted matter would remain near the shore.

This policy of attempting to avoid pollution by placing the intake cribs as far out in the lake as practicable has been followed in locating each of the six cribs since constructed. The Two-Mile, Lake View, Sixty-eighth Street,

and Edward F. Dunne cribs are offshore approximately two miles; the Carter H. Harrison and the new Wilson Avenue cribs, about three miles; and the Four-Mile crib, about four miles.

Efforts to Prevent Pollution by Diverting Sewage from the Lake

The construction of intake cribs at from two to four miles out in the lake improved the quality of the water supply, but the theory that the sewage and other filth flowing into the lake from the river and from the sewers along the lake shore would remain near the shore line was soon shown to be fallacious. At times the City suffered greatly from the contamination of the water supply brought about by the discharge of the polluted contents of the river into the lake. Ultimately the necessity for keeping the sewage away from the lake was realized, and attention was turned to diverting the flow of both the river and the sewers.

The Illinois and Michigan Canal, connecting the south branch of the Chicago River with the Illinois River at La-Salle, Illinois, which was opened in 1848, was enlarged between 1866 and 1871 so as to take a greater quantity of water from the Chicago River and thus to dispose of a greater amount of Chicago's sewage. Again in 1886 the flow from the river to the canal was increased, the intention being in each case to take more water into the canal at the head and in that way to cleanse and purify the river. This means of diverting sewage from the lake proved wholly inadequate, however, and in 1889 the construction of the Sanitary District Drainage Canal was authorized by the Legislature.*

*The Sanitary District Drainage Canal extends from the Chicago River at Robey Street southwest nearly to Joliet, Illinois, a distance of 30 miles. The channel is under the jurisdiction of the Trustees of the Sanitary District of Chicago, a quasi-municipal corporation independent of the City government proper.

The drainage canal, which was put into operation in 1900, reversed the flow of the Chicago River. Following the completion of the canal, two intercepting sewers were constructed, one extending from Eighty-seventh Street (near the mouth of the Calumet River) north to Thirty-ninth Street, and the other from Howard Avenue (the northern limits of the city) south to Diversey Boulevard. These intercepting sewers receive the sewage which formerly flowed into the lake between the points named and carry it to Thirty-ninth Street on the south and to Lawrence Avenue on the north, where it is pumped into east and west conduits and carried to the south and north branches of the river, respectively. Between Thirty-ninth Street and Diversey Boulevard the sewers which formerly flowed into the lake were diverted directly to the river.

With the completion of the intercepting sewer system in 1908, there still remained the problem of turning back the sewage of the cities and villages north of the Chicago limits, and also the problem of the Calumet River, which is in a highly polluted condition and is discharging its contents into the lake.

To accomplish the diversion of the north shore sewage and to supply water for its dilution, the Sanitary District constructed the North Shore Drainage Canal which extends from the lake shore at the Village of Wilmette to the north branch of the Chicago River near Lawrence Avenue, a distance of eight and one-half miles. This channel was completed in 1911. A system of intercepting sewers, designed to collect the sewage of the north shore communities between the Chicago limits and the Cook County line and to carry it to the north shore channel, thus diverting it from the lake, is now under construction, and will probably be completed in 1919.

When the north shore intercepting sewers have been completed no sewage will be discharged into the lake between the northern limits of Cook County and the mouth of the Calumet River, a distance of more than 30 miles. The efforts of the City of Chicago and of the Sanitary District in this direction will not, however, operate to prevent the municipalities situated north of Cook County as well as those along the Indiana shore from discharging their sewage into the lake.

In an effort to solve the Calumet River problem, the Sanitary District is also building a channel from Stony Creek on the Little Calumet River to the Main Sanitary District Canal at a place called Sag. This Calumet-Sag Channel is designed to divert the flow of the Calumet River from the lake, and a system of intercepting sewers will collect practically all the sewage south of Eighty-seventh Street, which now empties into the Calumet River, and carry it directly to the new channel. It is expected that this work will be completed in 1919.

The Calumet-Sag Channel and its intercepting sewer system will divert the sewage now discharged into the Calumet River and, under normal conditions, will reverse the flow of the river, producing a slow current away from the lake. It is not claimed for this project, however, that it will be large enough to accommodate the flood waters of the Calumet, which during periods of heavy rainfall may be expected to continue discharging into the lake, carrying with them more or less polluting matter.

Present Condition of Lake Water at Chicago

Typhoid fever being largely a water-borne disease, any material improvement in the quality of a city's water supply is usually reflected in a lower typhoid death rate. In fact, the typhoid death rate of a city is quite generally taken as the measure of the purity of its water supply.

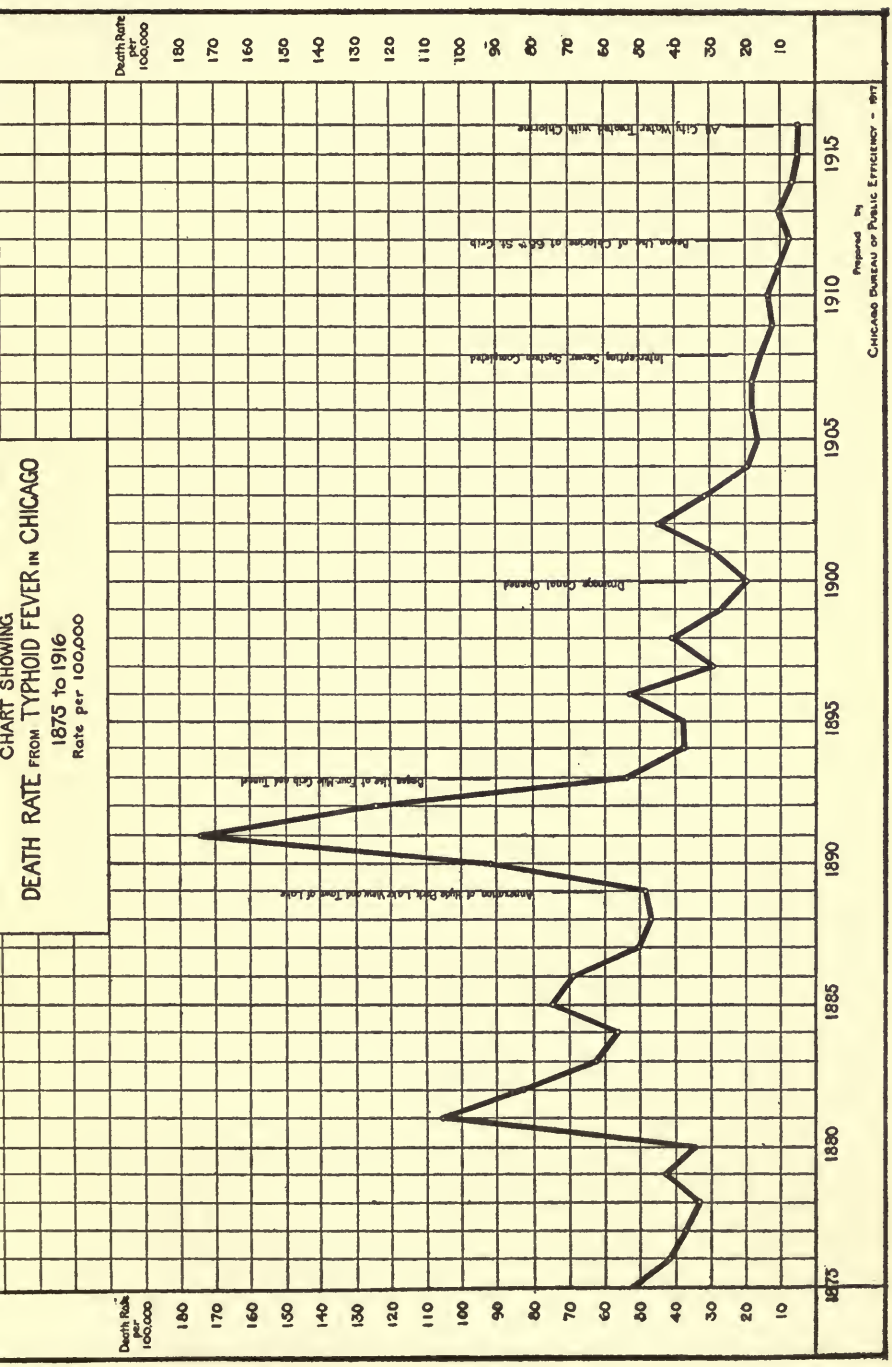
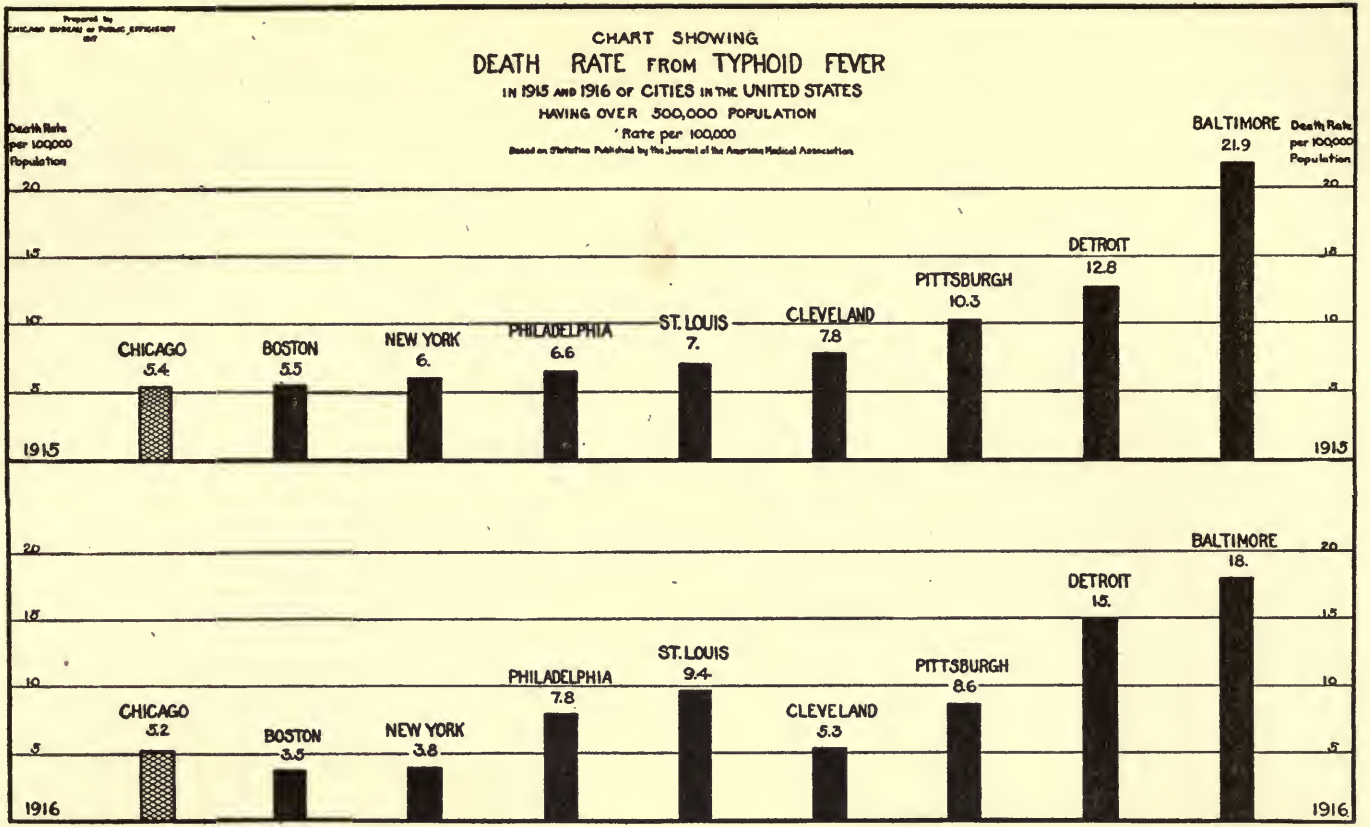


CHART SHOWING
DEATH RATE FROM TYPHOID FEVER IN CHICAGO
1875 to 1916
Rate per 100,000
Death Rate per 100,000
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1875
1880
1885
1890
1895
1900
1905
1910
1915
Annexation of Hyde Park, Lake View and Town of Lake
Bogue Use of Four-Mile Crib and Tunnel
Drainage Canal Opened
Intercepting Sewer System Completed
Beacon Use of Chlorine at 65th St. Crib
All City Water Treated with Chlorine
Prepared by
Chicago Bureau of Public Efficiency - 1917

The chart on page 95 shows the typhoid death rate of the City of Chicago for a period of years. It will be noted that the opening of the Sanitary District Canal in December, 1900, and the consequent reversal of the flow of the Chicago River did not apparently affect the situation so long as the sewers continued to discharge into the lake, but that since the completion of the intercepting sewer system the typhoid death rate has steadily decreased, except in 1913 when there was a small typhoid epidemic.

The chart opposite shows comparatively the typhoid death rate of Chicago and eight other cities of the United States having a population of over 500,000 for the years 1915 and 1916. It will be noted that in 1915 the Chicago rate of 5.4 per 100,000 of population was as low as that of any large city in the country. In 1916, however, while the Chicago rate showed a slight improvement, being 5.2, both Boston and New York showed a lower rate than Chicago. An unfortunate accident, which resulted in the backing-up of the sewage in the territory adjacent to the Sixty-eighth Street pumping station and in the contamination of the wells at that station, caused an epidemic of typhoid in the district supplied by it. This accounts in part for the failure of Chicago to attain a lower rate. Officials of the Chicago Health Department report a rate of approximately 1.76 for 1917, which they say is about one-half as high as the rate of either New York or Boston.

The use of chlorine in sterilizing the water, which was introduced at the Sixty-eighth Street and Lake View intakes in 1912 and 1913, and was extended to all the pumping stations during 1915 and 1916, has been an important factor in improving the condition of the supply. In view of this and of the fact that general conditions of sanitation are improving, it is probable that a further



NOTE—Officials of the Chicago Health Department report a r ate of approximately 1.76 for 1917, which they say is about one-half as high as the rate of either New York or Boston.

reduction in typhoid cases may be expected in future years. On the whole, however, the typhoid death rate of Chicago at the present time compares favorably with that of other large cities both in this country and abroad.

It would be a mistake, of course, to credit the lowering of Chicago's typhoid rate entirely to its improved water supply. The typhoid rate, which is influenced also by the milk supply, the general sanitation of the community, and the precautions taken to prevent the spread of the contagion when once started, has been declining everywhere, due to improvement in the conditions mentioned. It is claimed by the Chicago Health Department that the more rigid enforcement of the ordinance requiring the pasteurization of milk has played an important part in reducing the rate in this City in recent years.

The steady decline of the typhoid death rate following the completion of the intercepting sewer systems is perhaps the best indication of the success which has attended Chicago's efforts to prevent the pollution of the lake water. However, the still further reduction of the death rate since the introduction of the chlorine treatment in 1912 tends to show that these efforts have not been entirely successful, and that the water at the cribs is still contaminated at times. This conclusion is borne out also by the analysis of the water made by the Health Department.

Under present conditions, the lake water at Chicago is exceptionally good a large part of the time. At other times it is badly polluted and unfit for drinking purposes unless sterilized or otherwise purified. There are several well defined sources of contamination.

1. The large district south of Eighty-seventh Street known as the "Calumet region" empties its sewage into the Calumet River, which with every

notable flood is flushed into the lake. It is said that the polluting matter discharged from the Calumet River materially affects the purity of the water of Lake Michigan for a distance from the river mouth of over 10 miles in every direction, depending upon the wind and the currents in the lake. The effect of this pollution has been felt for many years at the Sixty-eighth Street and Edward F. Dunne cribs, which are located about 4½ miles from the mouth of the river. The Calumet-Sag Channel, heretofore referred to, is being constructed to remedy this situation. Experts who have studied the subject have expressed the opinion, however, that the Calumet-Sag Canal will not of itself prove entirely effective as a preventive measure, since it will not be large enough to control the flood flows of the river.

2. Neighboring cities adjacent to Chicago still empty their sewage into the lake. This sewage is subject to the mercy of the winds and of the lake currents created by the winds, and undoubtedly at times affects the purity of the water supply. The water at the Lake View crib is perhaps most noticeably affected by this source of pollution at the present time. The north shore intercepting sewer system when completed will probably greatly improve the situation in this respect. However, after the north shore project is completed, cities and villages farther to the north, and even cities in Wisconsin, as well as the population rapidly coming into being along the coast line of Indiana, will continue to contribute their share to the increasing impurities in the lake water. Studies made in recent years have shown that the harmful effects of such impurities are not always confined to the immediate vicinity of

the cities contributing them. The extent to which polluting matter may spread and the distance which it may be carried by the winds and lake currents are not definitely known, but competent authorities have expressed the opinion that localities even twenty or thirty miles from the point of entrance of large quantities of sewage are not safe places from which to derive water for domestic use.

3. Since the opening of the drainage canal in 1900 the normal flow of the Chicago River has been away from the lake. It is a fact not generally appreciated, however, that at times the current of the river is reversed and flows directly into the lake. No public record of this movement is made, but it occurs because sudden barometric changes often lower the level of the lake quite suddenly—so suddenly in fact that the controlling works of the Sanitary District canal located at Lockport, 28 miles away, cannot be effectively adjusted in time to prevent a considerable outflow of contaminated river water into Lake Michigan. Mr. John W. Alvord informs the Bureau that he has personally observed a reversal of this kind on three separate occasions within the last eight years.

4. The general increase of population along the lake shore, over the 25 or 30 miles of lake front which is now thickly inhabited, has undoubtedly led to increased pollution of the lake waters from various industries, bathing beaches, and other minor causes. That this is true is well shown by a bacterial survey made by the Chicago Health Department some years ago, which survey shows that objectionable bacteria are found in considerable quantities immediately along the shore and, in gradually diminishing number, much farther out in the lake than it had been previously supposed they would be found.

5. It has been the practice for many years to dump into the lake dredgings from the Chicago River and other refuse from the City. Since 1910 the Federal Government has forbidden dumping within eight miles from the shore, unless the material is placed behind bulkheads where it cannot run into the lake. A City ordinance, also, prohibits any dumping within 13 miles from shore. City authorities are devoting considerable effort to enforcing these regulations, but there is a very serious doubt as to whether they are at all times complied with. Moreover, even where the dumping takes place outside the prohibited area, refuse matter is often washed from the decks, and sometimes from the holds, of the scows by the waves during times of storm. Refuse similar to that observed on scows and in the lake in their track has been caught on the screens over the intakes at the cribs.

6. The several thousand lake boats entering and leaving the Chicago harbor each year, many of which pass in close proximity to the Two-Mile and Carter H. Harrison cribs, undoubtedly contribute polluting matter to the waters in the vicinity of the intakes of these cribs. The enforcement of sanitary regulations as to the disposition of sewage and refuse from these vessels, especially passenger and excursion steamers, has greatly improved conditions in this respect during the past few years, but it must be obvious that this form of pollution is not and cannot be effectively controlled. One of the dangers arises from vessels taking water ballast in polluted harbors and subsequently discharging it near the intake cribs.

7. Storms frequently stir up the bottom of the

lake, dislodging contaminating matter which may have been deposited there or which has collected there from natural causes.

The Chicago water supply is not polluted at all times. In fact it is polluted but very little of the time. No one of the sources of pollution above described is continuous or uniform. Each is occasional only, depending largely upon weather conditions and upon accidents of navigation. The dangerous conditions usually come on suddenly and quite unexpectedly and may disappear slowly. The degree of pollution varies. At some intakes it is worse than at others.

The fact that such pollution is accidental and occasional does not lessen the danger. In some ways it tends to increase it, since it may produce a false sense of security. The public should understand that a water supply is to be gauged by the worst conditions which arise and not by its average purity, and that it is not sufficient for the water to be free from contamination the greater part of the time. It is essential that it be pure all the time. A water supply polluted on but four or five days in a year may result in serious epidemics. Fortunately, the public officials of Chicago realize these facts and, in common with authorities of a large number of cities, are attempting to safeguard the supply against occasional pollution by sterilizing the water all the time.

Turbidity

The lake water is turbid or muddy at times. Frequently it is noticeably so, and after storms the turbidity often reaches 60 to 70 in the scale recommended by the Committee on Standard Methods of Water Analysis of the American Public Health Association. This is ten times

the degree of turbidity which is considered permissible for the best water supplies.

Turbidity is due to the stirring up of the bottom of the lake by storms. The extent to which the health of the community may be affected depends upon the quantity of bacterial impurities dislodged with the other sediment at such times. Turbidity may or may not be a public menace on that ground, but it always makes the water uninviting not only for drinking but for bathing and other domestic uses. As a result, household filters are frequently used, while many persons who can afford to do so buy bottled water for drinking purposes.

So far as bacterial impurities are concerned, they can be rendered harmless by sterilizing the water as is done at present. Sterilization, however, will not clarify the water.

The Need for Further Purification

Notwithstanding the success which has attended the efforts made to prevent its pollution, the lake water at Chicago does not possess the degree of purity which is desirable. While, so long as its sterilization is continued, it may be said to be no longer a serious menace to the health of the community, on the ground both of occasional pollution and of turbidity, it is below the standard which a city of the importance and civic ideals of Chicago should set for its water supply.

The completion of the north shore intercepting sewers and of the Calumet-Sag Channel project, the more rigid enforcement of sanitary regulations concerning lake vessels entering the harbor, and the further restriction of dumping in the lake should still further reduce pollution, but, even when all is done that can reasonably be done to prevent it, there will still remain the danger of chance pol-

lution which cannot be altogether eliminated. If bacterial purity alone were required, the continued sterilization of the water would probably meet the situation, although the treatment of the water with chlorine is likely to render it offensive at times to both taste and smell. The unpleasant taste and odor now frequently present in the water is due to the use of chlorine gas for purification purposes. As previously pointed out, however, sterilization by means of chlorine will not clarify the water. It is apparent, therefore, that if Chicago is to have water which is at all times clean and wholesome some means of purification other than sterilization must be adopted to obtain it.

Location of Intake Cribs as Related to Purity of Supply

The question naturally arises as to whether water of the requisite degree of purity can be obtained by locating the intake cribs farther out in the lake.

At the locations of the present cribs, from two to four miles offshore, the depth of water varies from 25 to 40 feet, although the intake ports are at a lesser depth. Intakes located at from 12 to 15 miles offshore would be desirable if it were practicable to construct them that far out, since at that distance the purest water in the vicinity of Chicago has been found, and at that distance also there is a depth of 50 feet or more, which is considered desirable in order to avoid turbidity. There is no certainty, however, that even at these points the lake water is entirely free from occasional contamination. Hence, the results to be obtained by moving the intakes might not be entirely satisfactory. It is probable, therefore, that in any event the City ultimately will have to filter its supply to avoid such pollution. In view of this, and of the almost prohibitive cost involved in extending

the tunnels and cribs out the desirable distance, it is considered impracticable to make such extensions.

Filtration

So far as the Bureau is informed, the only other plan which has been proposed for the purification of the Chicago supply, so as to eliminate both the danger of water-borne disease and of turbidity, is filtration. Messrs. Soper, Watson, and Martin, the experts who made the report heretofore referred to for the Chicago Real Estate Board, were unequivocal in their opinion that purification in this case means filtration. City Engineer Ericson has publicly stated that in the near future it must be resorted to. Mr. Alvord concurs in these views and says that few intelligent and enlightened cities of the size of Chicago would permit the municipality to serve its customers with such muddy water as is often served in this City for many weeks after storms.

No definite plans for the construction of filtration plants have been prepared, but the experts above mentioned state in their report that the process is neither experimental nor novel, and that it is entirely practicable for Chicago. Mr. Ericson's statement that in the near future filtration must be resorted to implies of course that it is practicable. Mr. Soper and his associates suggested that it be installed at first upon a reasonably small scale where most needed, and that it subsequently be extended as the requirements demand so as ultimately to protect the entire supply. They pointed out that "filtration will not do away with the need of exercising reasonable care in the disposal of the sewage and other waste in such localities as are likely to affect the quality of the water before it is filtered," but that if reasonable precautions are taken to keep out gross pollution filtration will adequately protect the water supply.

Public health authorities and the public generally are constantly demanding a higher standard of purity for domestic water supplies, and it is not to be expected that the people of Chicago will long be content with a supply which is inferior to that of other great cities of the world. It seems safe to predict, therefore, that in the not far distant future they will demand better water than is now being served and that the problem of a really pure, clean, and wholesome water supply with which the City has been struggling since its earliest days will be finally solved through filtration.

THE ADEQUACY OF THE SUPPLY

To render efficient service a water works should furnish an abundant supply of water for domestic, industrial, fire protection, and other public purposes. The pressure under which the water is delivered should be adequate and should be maintained with approximate uniformity throughout the twenty-four hours of the day.

The unlimited quantity of water close at hand greatly simplifies Chicago's problem of an abundant supply. The low and almost level surface of nearly the entire city is unusually favorable also for the transportation of the water from the lake to the premises of the consumers. Notwithstanding these favorable conditions, the Chicago Water Works has never been able to meet satisfactorily the requirements of efficient service. Large expenditures for additional tunnel and pumping equipment and for extensive additions to the distribution system have served to relieve the situation temporarily from time to time, but each year there have been, and there still are, constantly recurring complaints of a shortage of water and of insufficient pressure in various sections of the City.

Chicago Pressures Insufficient

A minimum pressure of from 35 to 40 pounds per square inch throughout the distribution system would probably be regarded as adequate, although the Committee on Fire Prevention of the National Board of Fire Underwriters has recommended a minimum pressure of 50 pounds during periods of maximum domestic consumption. If a pressure of from 35 to 40 pounds were maintained constantly throughout the day, it would be sufficient to supply an abundance of water on the fourth and fifth floors of apartment houses and on the fourth floors of most buildings used for industrial purposes. For fire protection there should be a sufficient quantity to enable fire engines to draw their supply at all times without taking the water from the hydrants under suction.

The pressure in many parts of the City is considerably below the standard indicated above. An effort is made to maintain a minimum of 25 pounds, but it is frequently impossible to do so.

The Staff of the City Council Committee on Finance in a recent report (April, 1917) estimated the pressure in the various wards as follows:

Ward	*Pressure (lbs.)*	*Ward*	*Pressure (lbs.)*	*Ward*	*Pressure (lbs.)*
1	25-31	13	19-22	25	21-33
2	22-27	14	19-22	26	27-29
3	26-28	15	16-19	27	12-36
4	24-27	16	16-19	28	16-19
5	23-25	17	17-19	29	12-23
6	22-23	18	21-23	30	22-24
7	30-31	19	22-25	31	23-25
8	34-36	20	22-25	32	32-35
9	37-50	21	18-20	33	13-27
10	22-25	22	18-20	34	20-23
11	22-25	23	18-20	35	18-20
12	20-23	24	21-25		

It will be noted that 28 of the 35 wards show a minimum pressure estimated at less than 25 pounds and that a minimum of less than 20 pounds is shown for 13 wards; also that in 16 wards the *maximum* pressure is estimated at less than 25 pounds.

The Bureau of Engineering maintains recording pressure gauges at various points scattered throughout the distribution system. The following table shows the average pressure registered by each of these gauges at certain hours of the day for the period of a week during the months of February, April, and July, 1917, respectively. The hours selected in preparing these tables represent approximately the hours of maximum and minimum consumption. Likewise, February and July represent periods of maximum midwinter and midsummer consumption due to the extensive use of water during the winter months to prevent freezing and during the summer months for cooling purposes. The readings for April indicate the situation at a time when these abnormal conditions are absent. The low pressures shown for 8 P. M. in July are due in part to the extensive use of the hose at that time for sprinkling purposes.

Table Showing Average Water Pressures at Various Points Throughout the City of Chicago for Certain Periods During 1917

Location of Gauge	Elevation Above Chicago Datum	Average Pressures*						
		Week Feb. 11–17, 1917		Week Apr. 22–28, 1917		Week July 29–Aug. 4, 1917		
		9 A.M.	3 A.M.	9 A.M.	3 A.M.	9 A.M.	8 P.M.	3 A.M.
*Lake View Pumping Station***	15.87	*35.4*	*35.6*	*38.1*	*36.6*	*38.6*	*35.4*	*34.8*
1219 LaFayette St.	10.49	29.7	31.1	34	34.7	32.9	29.4	32.6
2414 Cuyler Ave.	12.75	26.4	27.3	29.4	33.1	26.9	25.4	30.1
2322 Foster Ave.	32.70	14.6	17.2	17.6	21	15	11	18
1545 Rosemont Ave.	17.34	23.4	26	27	29.9	24.9	22	27.1
7077 N. Clark St.	26.23	23	26	26.6	29.7	19.4	15.7	25.7
1529 Belmont Ave	23.25	21.1	24.1	25.6	30.1	22.1	19.3	26.9
2756 N. Fairfield Ave.	16.21	...	...	21.3	26.7	16.9	17	23.7
*Chicago Ave. Pumping Station***	22.04	*28*	*29.4*	*27.9*	*31.1*	*27.8*	*31.6*	*29.3*
119 N. Franklin St.	15.85	...	...	29.3	34.5	25.2	31.2	30.5
522 Webster Ave.	21.11	18.1	21.4	21.9	26.7	18.5	18	24.9
59 E. South Water St.	16.46	26	30.1	28.8	33	25.1	29.6	30.6
1129 W. Chicago Ave.	15.30	14.3	17.6	19.7	21.9	12.1	18	21
1623 N. Robey St.	16.24	15.1	18.9	20.3	26	16.3	17.5	21.6
*Harrison St. Pumping Station***	25.35	*29*	*31.3*	*31.1*	*33.1*	*31.1*	*32.1*	*34.1*
540 Washington St.	15.27	20.4	24.4	25.3	30.7	21.3	24.7	29.5
*Fourteenth Street Pumping Station***	26.80	*25.1*	*29.4*	*29*	*35*	*24*	*28.4*	*32.3*
14 W. Taylor St.	15.16	29.6	33.4	32.1	37.4	27.4	32	34.7
23 W. 31st St	15.09	23.3	26.7	28.7	34.3	23.5	28	31.8
3444 Rhodes Ave.	19.93	22.7	27.1	27	33.1	19.4	21.7	28
4600 Cottage Grove Ave.	16.62	25.7	31	31.4	37.7	27.4	26.4	34.7
*Twenty-second St. Pumping Station***	24.68	*24.7*	*26.6*	*30.7*	*32.1*	*26.6*	*29.6*	*29.1*
1618 33rd Place.	14.29	21.1	24.7	27	34.9	22.3	25.3	29.6
1642 W. 47th St.	16.60	19	24.4	26.4	32.3	19.9	22.1	29
43rd St. and Center Ave.	14.09	19.3	24.4	25.3	30.1	17.3	21	27.7
2258 W. 13th St.	14.20	19.3	22.4	26.1	30.7	20	23.7	27.1
*Sixty-eighth St. Pumping Station***	13.00	*35.4*	*39.6*	*42.4*	*45*	*41.5*	*39.7*	*42.3*
6017 State St.	22.56	22.4	28.1	27.7	33.1	27.1	28.3	31.1
6245 Dorchester Ave.	18.51	31.7	36.7	35.7	40.4	32.4	33	37.6
9321 S. Chicago Ave.	12.10	33.6	33.8	39.1	37.7	34.1	32.7	34.4
5300 Wentworth Ave.	18.11	20.9	26.7	28.4	35.3	23.6	25.5	31.7
6244 Laflin St	15.88	22.6	27	28.9	33.1	23.4	22.7	28.4
3500 W. 60th St.	26.82	19.7	23.5	25.4	30.4	18.3	19.6	25.7
7531 Dobson Ave	7.96	38.1	41.9	44.1	46.6	41.4	40	44
5601 W. 63rd St.	38.4	11.1	14.7	18.1	22.7	12.8	13.5	17.6

Table Showing Average Water Pressures at Various Points Throughout the City of Chicago for Certain Periods During 1917—Concluded.

Location of Gauge	Elevation Above Chicago Datum	Average Pressures*						
		Week Feb. 11–17, 1917		Week Apr. 22–28, 1917		Week July 29–Aug. 4, 1917		
		9 A.M.	3 A.M.	9 A.M.	3 A.M.	9 A.M.	8 P.M.	3 A.M.
*Roseland Pumping Station***	27.20	*47.7*	*37*	*48*	*37*	*43*	*39*	*33*
13359 Burley Ave.	7.07	29.1	29.4	37	36.3	30.6	29	30.6
623 E. 108th St.	13.89	47.3	39.9	49.1	41.4	47	44	38.4
12054 Wallace St	35.82	35.3	26.7	37.1	29	36.9	34.4	26.4
8630 Emerald Ave.	20.13	31.9	29.7	34.4	33.1	32	30.1	29.8
10458 Hoxie Ave.	6.44	34.1	33.7	40	38.4	38.1	37	35.3
13401 Indiana Ave.	13.91	26.3	27.5	37	34.6	33	29.1	33
977 91st St.	7.6	35.7	35.9	40.7	39.7	40.3	39	39.1
*Washington Heights Booster System***	29.20	*55.8*	*52.2*	*55.1*	*54.9*	*53.1*	*54*	*52.7*
10400 Vincennes Ave	41.27	49	46.1	48.4	47.9	44.6	43	45
*Central Park Ave. Pumping Station***	29.48	*25*	*26.3*	*31.4*	*33.7*	*38.9*	*40.4*	*35.3*
2111 S. Hamlin Ave.	16.40	19.4	22.9	24.6	29.7	21.6	20.9	28.3
2444 Warren Ave.	17.25	17.1	20.6	23	29.3	16.7	19.3	25.1
4658 Lexington St.	27.40	17.9	21.6	24.4	29.7	18.4	21.1	26
*Springfield Ave. Pumping Station***	31.16	*26.7*	*26.9*	*28.4*	*33.1*	*36.3*	*35.8*	*35.1*
1640 N. Kostner Ave	27.30	23.6	25	26.3	31.1	18.1	19.7	26.4
439 N. Waller Ave	39.85	13.7	16.6	19.3	24.8	17.6	15	23.7
816 N. Laramie Ave.	36.33	18.3	22	22.6	28.9	20	17.5	25.4
4837 Lipps Ave.	34.74	31.7	34.9	31.7	42.9	27	21	35.6
*Jefferson Park Pumping Station Suction***	37.95	*9.4*	*12.9*	*14.4*	*19.9*	*10*	*7*	*15.1*
*Jefferson Park Pumping Station Discharge***	37.00	*55.1*	*52.1*	*58.1*	*55.4*	*55.6*	*46.3*	*52*
N. Sayre & Medill Aves.	73.02	...	...	25.6	31.9	34.7	22.8	35.7
6030 Avondale Ave.	60.86	32.6	33.1	39.7	40.7	31.1	22.4	36
Average.		25	27.4	29.5	33	25.5	25.2	29.9

* Pounds per square inch.

** Not included in average.

It will be noted that during each of the three periods indicated in the foregoing table, with few exceptions, all the gauges show pressures of less than 35 pounds, which as above explained is the minimum which should be maintained to insure satisfactory service.

It will be noted also that the average pressure at 9 A. M. for the July week was only 25.5 pounds. For the February week it was only 25 pounds. During these periods many of the gauges registered less than 25 pounds and several of them less than 20 pounds. In February one-third of the number showed less than 20 pounds. Even during the month of April when there was no unusual demand on the pumping equipment the average pressure was only 29.5 pounds, and one-fourth of the gauges registered less than 25 pounds. Moreover, the pressures shown do not reflect the worst conditions. Most of the gauges are located near large feeder or supply mains. At greater distances from these large supply mains pressures undoubtedly were much lower than those indicated.

The Effect of Low Pressures

These low pressures mean that, in most parts of the City, water is not being supplied above the third floors at any time, and that during periods of maximum demand there is a failure to supply third floors. In some sections of the City the service is not satisfactory and uninterrupted even on the lower floors. Consumers living near pumping stations or adjacent to large supply mains usually have little cause for complaint, but those not so situated are frequently deprived of the use of water.

Fire Protection Service

As to fire protection, in most parts of the City there is enough water for the engines, although the pressure is

not always adequate and there is some danger that in case of any considerable fire remote from a large main there might be an insufficient supply. The Committee on Fire Prevention of the National Board of Fire Underwriters in a bulletin issued March 28, 1916, said that the margin of supply available for fire draft was "small and generally insufficient." This is particularly applicable to conditions during periods of maximum midwinter and midsummer consumption.

Separate systems of high pressure distribution mains and pumping equipment for fire protection purposes in (1) the district between Chicago Avenue and Twenty-second Street, east of Halsted Street, and in (2) the stockyards area have been under consideration by City officials for several years, but no definite action has been taken on the proposals outlined. The Bureau has not undertaken to make a study of the problems involved in providing such systems.

Low Pressures Due to Excessive Friction Losses

A further examination of the pressures shown in the foregoing table discloses some additional facts of interesting significance.

In transporting water through pipes, a certain amount of the pressure transmitted to it at the pumping station is lost through the frictional resistance of the pipes to the flowing water. Increasing the velocity of the water increases the friction, and therefore the loss of pressure. Because of these facts the pressure at any point distant from the pumping station is at all times less than the pressure at the station; also, as velocities increase during the times of the day when the consumption of water is greatest, pressures at outlying points fall, unless the pressure at the station is raised so as to offset the addi-

tional loss of pressure on the mains due to the increased velocities and the resulting increase of friction at such times. Consequently, in an efficient plant, the pressure at the station is raised and lowered from time to time as the amount of water consumed increases and decreases, the station pressure reaching its maximum during the hours of maximum consumption. In this way uniformity of pressure is maintained at outlying points.

In an efficient plant the *highest pressures at the pumping stations* are found *during the hours of greatest consumption.* It will be noted from the foregoing table that the *pressures at the Chicago stations* are quite generally *lowest at such times.* This is due to the fact that as the periods of greatest consumption approach and the demand for water increases it is drawn out of the mains faster than the pumps, working at full capacity, can push it into the mains. As a result it is impossible to prevent pressures at the stations from falling at such times, whereas they should be raised to offset the increasing pressure losses then occurring. Chicago is said to be one of the few cities in the country where a condition of this kind prevails. A fall in pressures at the pumping stations of course means a further lowering of pressures throughout the distribution system.

From the foregoing table it will be noted also that between the pumping stations and the locations of the outlying gauges variations in pressure occur which frequently amount to more than 10 pounds and sometimes to more than 15 pounds. This is due to the excessive velocities of the water flowing through the mains. Lowering these velocities would reduce pressure losses and would thereby automatically increase the pressures under which water is delivered to consumers, thus greatly improving the service. Excessive velocities are unavoid-

able, however, under existing conditions because the mains are required to transport an enormous quantity of water, much of which, as hereinafter pointed out, is subsequently lost through waste and leakage. When compared with pressures maintained in July, 1916, the July, 1917, pressures show a general tendency toward an increase at the pumping stations and toward a decrease at outlying points. The pressure losses are therefore greater this year than a year ago, indicating that conditions due to waste and leakage are becoming worse rather than better despite the efforts of the water works officials to improve them.

Curtailment of Water Waste a Paramount Need

The conditions just described account for the present shortage of water and insufficient pressures which result in depriving many consumers of uninterrupted and satisfactory service.

The inadequacy of the Chicago supply is not due to any lack of equipment. The pumping machinery and the distribution mains now in operation are sufficient to supply every reasonable requirement of a city of twice the population of Chicago. The difficulty is due entirely to the vast amount of water which is lost through waste and leakage.

Reducing the amount of water lost through waste and leakage will reduce the amount which must now be forced through the distribution mains. A reduction in the amount transported through the mains will mean lower velocities and accordingly less friction and reduced losses of pressure. Thus the immediate effect of materially reducing waste and leakage will be to improve immeasurably the present service by increasing existing pressures. Reducing waste and leakage will also result in

cutting down operating expenses and in eliminating the necessity for many future extensions of the plant, thus effecting very large economies. Further, the amount of water wasted has an important bearing on the problem of filtration and will be an important factor in the problem of sewage disposal if Chicago shall in the future provide for such disposal by other than the dilution method now employed.

The curtailment of water waste and leakage therefore has become by far the most important immediate water works problem for the people of Chicago to deal with.

V. WATER WASTE AND LEAKAGE

The water pumped by the Chicago Water Works every day during 1916 averaged 645,000,000 gallons—a volume sufficient to make a lake 20 feet deep and a mile long by one-sixth of a mile wide, or an area equivalent to that bounded by Madison, Twelfth, State, and Clark Streets.

It is conceded by every person familiar with the situation that this pumpage is more than twice the quantity required to furnish an abundant supply for domestic, business and other uses. Not all the water pumped is *used,* however. In fact the difference between the water pumped and the water actually used is very large. It has been roughly estimated that from one-third to one-half of it is *used.* The remaining one-half or two-thirds is frequently said to be *wasted.*

"Use" and "Waste" Defined

The term "wasted" as thus used is likely to imply more than it should. This is to be regretted, because it tends to create the erroneous impression in the minds of water users that measures designed to check "waste"

will result in restricting the "use" of water. Much of the opposition to waste control grows out of this erroneous impression which unfortunately quite generally prevails.

The "use" of water as the term is used in this report includes every legitimate use to which water can be put for domestic, industrial, and municipal purposes, including water for sprinkling streets and lawns, extinguishing fires, flushing sewers, and every other purpose for which water is necessary or has any real value.

The terms "waste" or "waste and leakage" as used in this report embrace all water pumped in excess of that required for legitimate use as above defined.

While not all the water pumped is "used," neither is all the water lost "wasted" in the ordinary sense of the term. *Some of it slips back through the pumps* and so does not enter the distribution mains; *some of it escapes* through innumerable leaks, many of them small, in cracked or broken mains, through imperfect joints in the mains, through broken or defective service pipes, through worn-out or defective shut-off valves, through worn-out packing around valve stems, and through blown-out or leaky hydrants; *some of it is lost* through leaky pipes and plumbing fixtures on the premises of the consumer; *some of it is wasted by the consumer* either wilfully or through carelessness, thoughtlessness or shiftlessness. The remainder of the water pumped is actually *used.*

Reducing Waste Does Not Mean Restricting Use

The aggregate loss of water in Chicago from the sources above mentioned is enormous. The extent of this loss and its effect, in various ways, is discussed in succeeding pages. It is very important, however, to understand clearly at the outset of this discussion that preventing

"waste" means reducing, as far as practicable, the loss of water through leakage and other causes, and that it does not mean curtailing or restricting any person in the "use" of as much water as he can use or is accustomed to use. It is neither necessary nor desirable to restrict the "use" of water. It should be supplied in abundance and its "use" encouraged. On the other hand, it is imperative to reduce "waste" and "leakage" to a minimum in order that every consumer may be given an abundant supply and satisfactory service.

These are important distinctions, and one phase of the "waste" problem lies in convincing consumers that reducing waste and leakage will not curtail their accustomed use of water, but will enhance the efficiency of the service and give them an abundant supply without in most cases increasing water bills. When this can be done, the opposition which now often arises to measures for the effective control of waste and leakage will disappear.

THE WASTE PROBLEM IN CHICAGO

The Situation Prior to 1900

The existence of an excessive amount of waste and leakage was recognized long prior to 1900, but it was not until about that time that it began to cause alarm and to receive the serious attention of City officials.

Prior to 1889 the water supply problem had been largely a question of increasing the water works plant so as to meet the demands of a rapidly growing population. The annexations of that year (Hyde Park, Lake, Lake View, and Jefferson—126 square miles of territory) and to some extent those of subsequent years brought with them another problem of an entirely different nature.

The City of Chicago and the various towns and cities which were annexed to it had each added to its system

gradually, without any thought whatever being given to the possibility of the various systems being afterward joined and operated as a single system. After annexation, therefore, instead of one intelligently planned and developed system, the City found that it had on its hands a number of these independent systems, each more or less inadequate even for the district which it was designed to serve.

The situation in which the City thus found itself continued until 1897 when work was commenced on comprehensive plans designed to remedy the unsatisfactory conditions then existing. These plans, which were practically completed in 1900, contemplated the rehabilitation of these various detached systems and their unification, including the general overhauling of the pumping station equipment, which had become badly dilapidated, the installation of several additional pumping engines, and the laying of an elaborate system of large mains to connect existing mains, equalize pressures, reduce friction, and correct the mistakes due to lack of previous systematic planning.

In commenting on the situation at the close of 1898, at which time the plans were well under way, the Commissioner of Public Works in his annual report predicted that when the Central Park Avenue and Springfield Avenue stations, then under construction, were completed the plant would have a capacity "sufficient to supply a population of three and one-half millions, and always have a sufficient reserve for any emergency that may present itself."

Developments Since 1900

The two stations last mentioned were put into service in 1900 and 1901, respectively, at which time the popula-

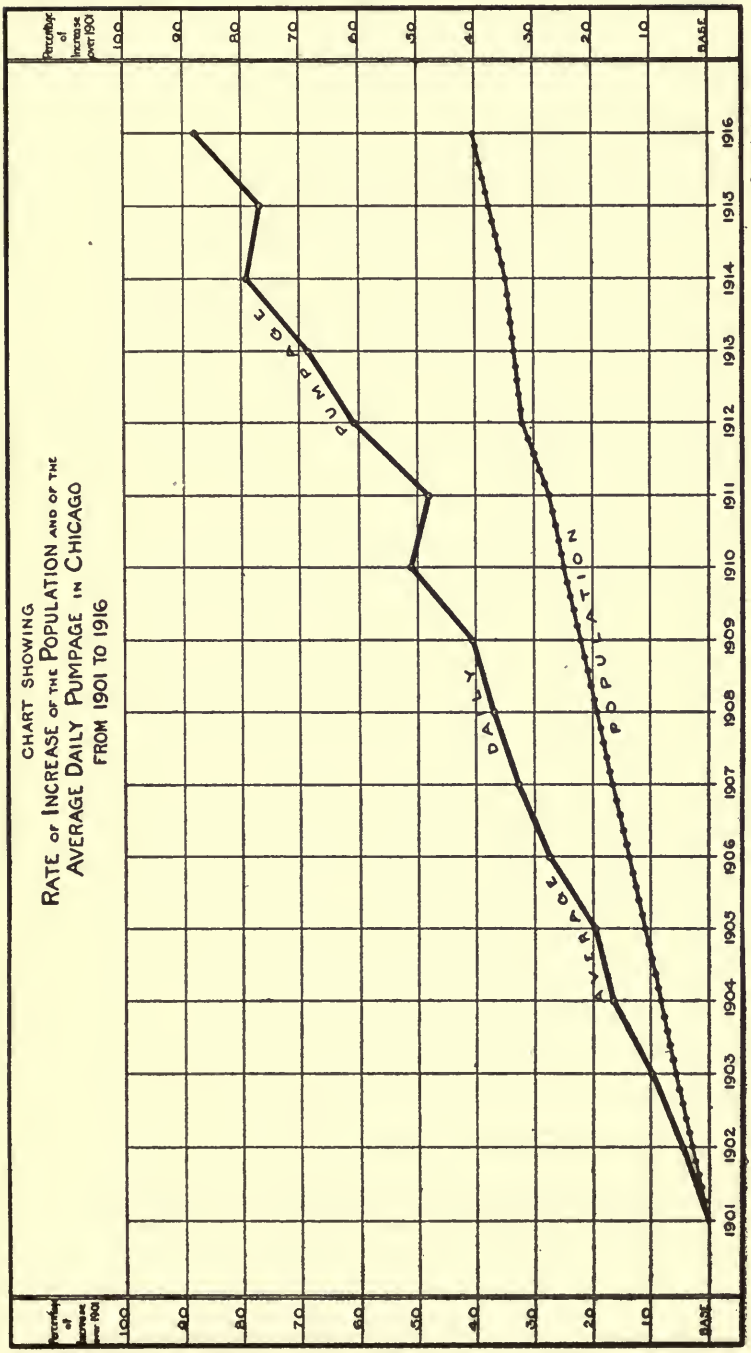


CHART SHOWING
RATE OF INCREASE OF THE POPULATION AND OF THE AVERAGE DAILY PUMPAGE IN CHICAGO FROM 1901 TO 1916
Percentage of increase over 1901
100
90
80
70
60
50
40
30
20
10
BASE
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
PUMPAGE
DAILY
AVERAGE
POPULATION
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

tion was estimated at 1,775,000. The plant then had a capacity sufficient for the requirements of nearly twice that number of people. Yet in his annual report of the following year (1902) the City Engineer said:

> "Our expectations of an abundant and satisfactory supply of water after the completion of many additions to the water works system in the last few years have hardly been verified. * * * There is a constantly growing demand for a greater supply of water. * * * The department must continue to increase the capacity unless the indisputable fact of a steadily growing and unnecessary waste and leakage is recognized and by systematic efforts eliminated."

What is even more significant, however, is that the whole development of the system since that time has been marked principally by the efforts of the City Engineer and his assistants to cope with this constantly increasing demand due largely to a steadily increasing waste and leakage. Since 1901 the capacity of the plant and the average amount of water pumped daily have nearly doubled, while the population has increased only about forty per cent and is even now far short of three and one-half millions. And yet the demand for more water is still insistent and further large additions to the system are contemplated.

The following table shows the increase in population, in total average daily consumption, and in average daily consumption per capita (per person) from year to year since 1901.

Table Showing Population, Total Average Daily Consumption, and Average Daily Consumption per Capita of Chicago for Years 1901 to 1916 (1)

Year	Population*		Average Daily Consumption**		Average Daily Consumption per Capita**
	Number	Percentage of Increase Since 1901	Gallons	Percentage of Increase Since 1901	Gallons
1901	1,776,236		342,901,000		193.0
1902	1,824,906	2.7	358,179,000	4.4	196.3
1903	1,873,576	5.5	376,090,000	9.6	200.7
1904	1,922,266	8.2	399,065,000	16.3	207.6
1905	1,970,936	10.9	410,930,000	19.8	208.5
1906	2,019,606	13.7	437,059,000	27.4	216.4
1907	2,068,276	16.4	455,194,000	32.7	220.1
1908	2,116,946	19.2	469,282,000	36.8	221.7
1909	2,165,616	21.9	480,905,000	40.3	222.0
1910	2,214,286	24.6	518,579,000	51.2	234.2
1911	2,262,956	27.4	507,332,000	47.9	224.2
1912	2,345,315	32.0	551,324,000	60.6	235.1
1913	2,372,000	33.5	577,860,575	68.5	243.6
1914	2,393,325	34.8	613,323,000	78.8	254.2
1915	2,447,000	37.7	606,707,671	76.9	248.0
1916	2,491,933	40.2	645,189,313	88.1	258.9

(1) Compiled from the annual reports of the City Engineer.
* Estimated from U. S. Government Census.
** Consumption by plunger displacement, no allowance being made for pump slippage.

Consumption of Water in Chicago Excessive

The average daily consumption per capita is the unit generally used in considering the reasonableness of the amount of water supplied to a community. A per capita consumption of 193 gallons, such as existed in Chicago in 1901, is very high and is conceded by water works au-

thorities to indicate excessive waste and leakage. It will be noted, however, that in the fifteen years which have since intervened, Chicago's per capita consumption has increased from 193 gallons to 259 gallons per day. Obviously, therefore, the waste and leakage, which in 1901 had begun to cause alarm in official circles, is very much greater today.

The rate of per capita consumption varies widely in different cities, the variations being due in a large measure to the amount of water used for industrial and business purposes and to the amount lost through waste and leakage. In large industrial centers like Chicago a per capita consumption of from 100 to 125 gallons per day may be expected, provided waste and leakage are kept under effective control. In cities of a largely residential character a much lower rate will ordinarily be found.

The following table shows the estimated population, the total average daily consumption, the daily per capita consumption, and the percentage of services metered for a number of American cities, arranged in the order of per capita consumption. The figures, which were obtained directly from officials of the various cities, are for the year 1916.

It will be noticed that the amount of water pumped in Chicago is 14 per cent greater than the entire supply of the City of (Greater) New York, the population of which is more than double the population of Chicago; also that the per capita consumption of Cleveland is 113 gallons, and that of Milwaukee 118 gallons. These figures, which like all the other figures in the table cover not only water "used" but water lost through "waste" and "leakage", are in striking contrast with Chicago's per capita of 259 gallons and indicate approximately the amount of preventable waste and leakage in the Chicago system.

Both Cleveland and Milwaukee are lake cities and important industrial centers in which conditions of consumption are similar to those in Chicago.

Table Showing Water Consumption Statistics of American Cities 1916

City	Estimated Population	Total Average Daily Consumption (gallons)*	Average Daily Consumption per Capita (gallons)	Percentage of Services Metered
Des Moines, Iowa.	105,000	6,300,000	60	98.5
Providence, R. I.	284,400	18,025,276	66	93
Oak Park, Ills.	33,000	2,260,000	70.6	100
New Orleans, La.	378,000	28,000,000	75	100
Madison, Wis.	32,050	2,480,000	77.4	99.8
Atlanta, Ga.	200,000	17,780,746	89	100
Kansas City, Mo.	380,000	34,000,000	89.5	80
Columbus, Ohio	216,687	19,617,448	90.5	96.1
Omaha, Neb	180,000	17,150,000	95	87.6
New York, N. Y.	5,602,000	566,200,000	101	26.8
Boston, Mass.	762,700	80,358,800	105	66
Springfield, Mass.	106,280	11,260,000	106	97.7
Cleveland, Ohio	845,000	95,672,973	113.2	98.4
Milwaukee, Wis.	440,000	54,885,366	118	99
Cincinnati, Ohio.	415,000	52,400,000	126.3	69
St. Louis, Mo.	755,000	97,712,000	130	7.1
Washington, D. C.	364,088	49,698,000	136.5	77
Los Angeles, Cal.	533,535	74,694,900	140	88
Detroit, Mich	781,133	131,654,068	168.5	36
Philadelphia, Pa.	1,700,000	300,000,000	176	15
Chicago, Ills.	**2,491,933**	**645,189,313**	**258.9**	**6.9**
Buffalo, N. Y.	486,000	159,838,036	329	5

* Based on plunger displacement, no allowance being made for slippage.

WHAT BECOMES OF THE WATER PUMPED IN CHICAGO

No data exist showing definitely what becomes of the water pumped in Chicago—how much of it is used in the industries, how much is used for domestic purposes, how much goes to public uses or how much is lost through leakage, waste and other causes. Where metering prevails to such a limited extent as it does in Chicago, it is practically impossible to obtain definite data of this sort. However, both the investigations of the Chicago city authorities and the experience of other cities make it possible to approximate what becomes of the Chicago supply.

Estimate of City Engineer

As a result of water waste surveys conducted several years ago, Mr. John Ericson, the City Engineer, concluded that the water actually "used" amounted to 102 gallons per day per capita, distributed as follows: 47 gallons (registered) to meter consumers, 40 gallons to flat rate consumers, 10 gallons free service, 5 gallons passing through meters and used, but not registered by the meters.

Both Milwaukee and Cleveland, which as heretofore pointed out are lake cities in which conditions of consumption are similar to those in Chicago, report the total amount of water "used" as equivalent to a daily per capita of approximately 96 gallons. An estimate of 102 gallons for Chicago would therefore seem to be large enough to cover the water actually "used" for all purposes.

Consumption Classified According to Uses

Water consumption is also sometimes classified in accordance with the various purposes for which water is

used, such as industrial, commercial, domestic, and municipal (public) uses.

Definite statistics giving such information cannot be obtained for Chicago under present conditions, and the following attempt to classify the Chicago consumption on such a basis must of necessity be predicated on the exceedingly meager data available so far as this City is concerned and upon the general experience of other communities.

Industrial Consumption

The total amount of water accounted for by meters in Chicago during 1916 was equivalent to a daily per capita consumption of 52 gallons. Six hundred of the larger industrial and commercial consumers now use more than half of this metered supply and by far the greater part of the remainder is used for industrial and commercial purposes. The proportion of the metered supply used by domestic consumers is relatively small. It may safely be assumed, therefore, that the total amount of water used for industrial and commercial purposes is approximately the same as the total metered supply, or about 50 gallons per day per capita. The fact that a part of the metered supply is used for domestic purposes is partially offset by the fact that not all the industrial and commercial consumption is metered.

Domestic Consumption

The amount of water required for domestic purposes is variously estimated by water works authorities at an average of from 35 to 45 gallons per day per capita. This allowance includes a sufficient supply for all purposes in and about dwelling and apartment houses, including water for sprinkling lawns and unpreventable waste and

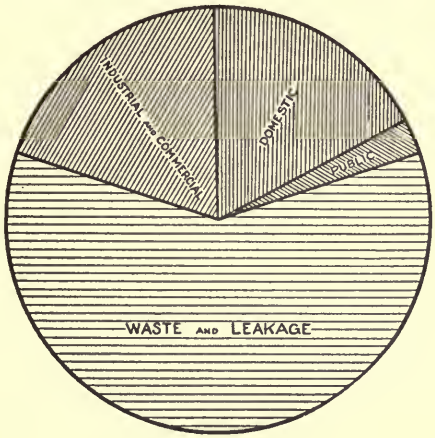
leakage. Within a comparatively few years much lower estimates were prevalent, but the requirements of better living conditions and the more general installation of facilities for using water have resulted in a general increase in domestic consumption. The Committee of the City Club [of Chicago] on Water Waste, Prof. Edward W. Bemis, chairman, in a report made in 1915 placed the amount required for domestic uses at 35 gallons per capita per day. Milwaukee reports a daily per capita use of 36.25 gallons in 1916 for dwellings, *offices, retail commercial establishments, stores, and other places where water is not used primarily for power or industrial purposes.* Cleveland in 1914 (the last year for which a report is available) accounted for a *total* per capita use of 96 gallons. Making allowance for its large industrial and business consumption and for the water used for public purposes, the domestic consumption probably was less than 40 gallons. Oak Park, Illinois, one of Chicago's suburbs (population 33,000) in which high class dwellings and apartment houses predominate and where there is a large quantity used for sprinkling lawns, in 1915 (the last year for which the information is available) reported a per capita use of 42 gallons for domestic purposes.

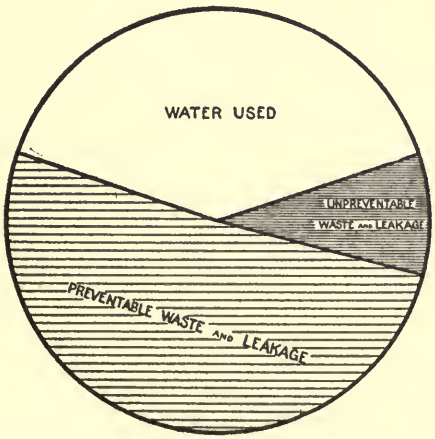
An average of 40 gallons per capita per day is therefore probably ample for domestic purposes in Chicago. Indeed, it is doubtful whether the exclusively "domestic use" of water in Chicago can exceed that amount. Certainly 45 gallons per capita would cover every requirement and provide an abundant supply.

Municipal Consumption

Municipal consumption includes water used for public buildings, schools, charitable institutions, street washing

DIAGRAMS BASED UPON THE
ESTIMATED DISTRIBUTION OF WATER PUMPED
IN CHICAGO IN 1916





Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

and sprinkling, fires, public comfort stations, flushing sewers and water mains, public baths, parks and fountains, testing meters, and other public uses. There are practically no data to show how much water is used for such purposes in Chicago, but, if properly controlled, seven gallons per day per capita would probably be sufficient.

Assuming, therefore, that the maximum amount of water used is equivalent to a daily average of 102 gallons per capita—50 gallons for industrial and commercial uses, 45 gallons for domestic consumption, and 7 gallons for public purposes—the amount lost through waste and leakage in 1916 was equivalent to 157 gallons a day per capita.* This was more than 60 per cent of all the water pumped. As hereafter pointed out, of the 157 gallons per capita that was lost 134 gallons could have been saved.

WASTE AND LEAKAGE

The water lost through waste and leakage may be divided into two general classes, each of which may in turn be further sub-divided as follows:

Water Lost in Delivery

I. Water lost in delivery through
   1. Pump slippage
   2. Leaks in the distribution system
      (a) breaks in mains
      (b) leaks in pipe joints, due to defective calking, settlement of ground, interference by other excavations, or electrolysis

*Average daily pumpage per capita (gallons) 259—102=157. See table, p. 121.

(c) leaks in mains due to small cracks and other imperfections and to the effects of electrolysis

(d) blown-out and leaky hydrants and small leaks around valve stems

(e) service pipes leaking or broken off at connection with main

(f) worn-out or defective service pipes, many of which have been installed but never used

(g) leaks around defective service cocks (at buffalo boxes)

(h) service pipes abandoned without curb ends being properly closed.

Water Lost on Premises

II. Water lost on premises through

1. Leaky service pipes on premises
2. Leaky plumbing pipes often due to careless or defective work
3. Leaky plumbing fixtures
   (a) leaky faucets
   (b) leaky water closets—ball and stop
   (c) water closets run continuously—intentionally
   (d) old-fashioned hopper closets
   (e) frozen service pipes or plumbing
4. The open faucet
5. Leaks in tanks
6. Leaks in automatic sprinkler systems
7. Leaks in hydraulic elevators.

Apparent Losses

In addition to the water actually lost, there is also an apparent loss due to water being stolen through illicit connections and by building contractors, or through auto-

matic sprinkler systems where they are not under meter, and due also to the unreported use of water for washing and sprinkling streets, for extinguishing fires, for insurance tests, for flushing mains, for filling new mains, for emptying and filling mains for repairs, etc., and for flooding trenches. Much of the water used for these latter purposes can and should be reported and accounted for as consumption for "municipal" purposes, but under the most favorable conditions it is inevitable that some will not be accounted for and will be attributed to waste and leakage.

Under-Registration of Meters

A still further apparent loss is due to water passing through meters without being registered. Under favorable conditions the water which the consumer receives and uses but which is not registered may be estimated at about 3 per cent of his total supply. However, in discussing preventable and unpreventable waste and leakage in this report the apparent loss due to under-registration of meters has been ignored because it is believed that a per capita allowance of 102 gallons is ample to cover all water "used" whether registered by the meters or not. In the consideration of what proportion of the "used" water would furnish a basis for fixing charges, the tendency of meters to under-register would of course be taken into account, although when meters are tested periodically the amount is so small that even in that connection it is not of much practical importance. Recognizing the fact that meters generally do under-register is useful principally in helping officials to account so far as possible for water pumped and thereby to detect and check the loss of water which cannot be accounted for.

PREVENTABLE AND UNPREVENTABLE WASTE AND LEAKAGE

It is not practicable to distribute water without some losses. An allowance must be made for pump slippage* and some leakage in the distribution mains and service pipes is unavoidable. Therefore, the waste and leakage in the Chicago system cannot be entirely prevented. A very large part of the loss due to waste and leakage can be eliminated, however.

Pump Slippage

The City Engineer in his annual report for 1916 estimates pump slippage at 3.62 per cent of the pumpage. This is a very low figure and shows a material reduction when compared with estimates of 1914 and prior years.

In order to keep pump slippage at a minimum it is essential that there be sufficient reserve equipment so that when a pump shows excessive slippage it may be shut down temporarily and repaired. Under present conditions of waste and leakage this cannot always be done. Notwithstanding the addition of several reserve pumps within the last few years, the capacity of the Chicago plant is so taxed during periods of high pumpage as to necessitate keeping pumps in operation after the slippage becomes several times the practicable minimum.

In view of these conditions it may be seriously questioned whether the actual pump slip at the present time is not considerably in excess of 3.62 per cent. It is believed, however, that with sufficient reserve equipment

*The capacity of a pump is determined by the maximum amount of water which it is capable of delivering with each stroke of the plunger. In practice, this maximum is frequently not delivered into the distribution mains on account of leaky pump valves through which the water "slips" back into the pump wells. The difference between the capacity of the pump and the amount of water which it actually pushes into the mains is called "pump slippage."

pump slip can be kept down to 5 per cent, or approximately 6 gallons per day per capita. Adding reserve equipment does not of course mean adding more pumps. The plant is now overbuilt for every reasonable requirement. What is needed is a condition of affairs under which more of the present pumps can be utilized for reserve. Such a condition can readily be brought about by reducing, through the elimination of waste and leakage, the amount of water to be pumped.

Leakage in the Distribution System

There are no definite data as to what part of the total loss through leakage is made up of the leakage in the distribution system, although the latter is known to be excessive. The water pipe extension division reports that surveys made in 1916 on 76 miles of mains indicate a loss of from five to ten per cent from this source. The leakage in the distribution system cannot be readily separated from the water delivered to the premises of consumers, because the stop cocks on the service pipes at the curb have fallen into disuse to such an extent that the services cannot be shut off during tests.

Leakage in the distribution system is due principally to defective mains and old service pipes. In discussing conditions found in connection with the extensive waste surveys conducted several years ago, the City Engineer in a report dated November 18, 1911, said:

> "The loss from defective street mains is due mainly to joint leakage, electrolysis, and occasionally to broken pipes. The joint leakage is found to be comparatively small, but the losses due to electrolysis are thought to be quite serious. The leakage caused by electrolysis is confined to sections or zones and is not believed to be serious over the general area of the city.
>
> * * *

"The most important underground leakage found is due to the old and unused and abandoned service pipes in the streets, that have opened or given way under pressure. The reason for this loss may be understood, when we stop to consider the great number of such service connections and the constant changes and liability to damage that service pipes are subject to, after installation.

"When a water main is laid or extended a service pipe is laid every twenty-five feet on both sides of the street. As the property along the street is improved, some of these services are connected up, but a great many of them are often never used. Later on, those in use are frequently replaced with larger ones. The buffalo boxes at the curb or walk, which were installed to control the services, very often disappear with street improvements, or for other reasons, so that the service pipe cannot be located. Unfortunately when a service pipe begins to leak the water usually finds its way to the sewer instead of showing on the surface of the street and the loss goes on indefinitely."

The conditions above described are believed to represent the present situation fairly well. The thousands of old, unused and abandoned service pipes present the most serious difficulty. Settlement of the ground has caused some of them to break off at the main; some have given way under pressure; others are leaking at the stop cocks; still others which were once in use have been abandoned, the curb ends being closed not by soldering but by hammering them together. Later these abandoned ends have opened under pressure, thus permitting the water to run continuously.

Leaks in mains and services cannot be entirely eliminated. It would be next to impossible to find many of the smaller ones, and even if located it would not pay as a matter of economy to uncover the pipes and repair them.

The larger leaks can be located and stopped, however,

and in that way one of the most important items of waste can be eliminated. Milwaukee (1916) has reduced leakage of this sort to approximately 17 gallons per capita per day, and Cleveland (1914) reported a loss therefrom of approximately 10.7 gallons per capita. It is believed that, if a systematic effort is made, in Chicago the leakage from this source can be reduced so as not to exceed 17 gallons per day per capita.

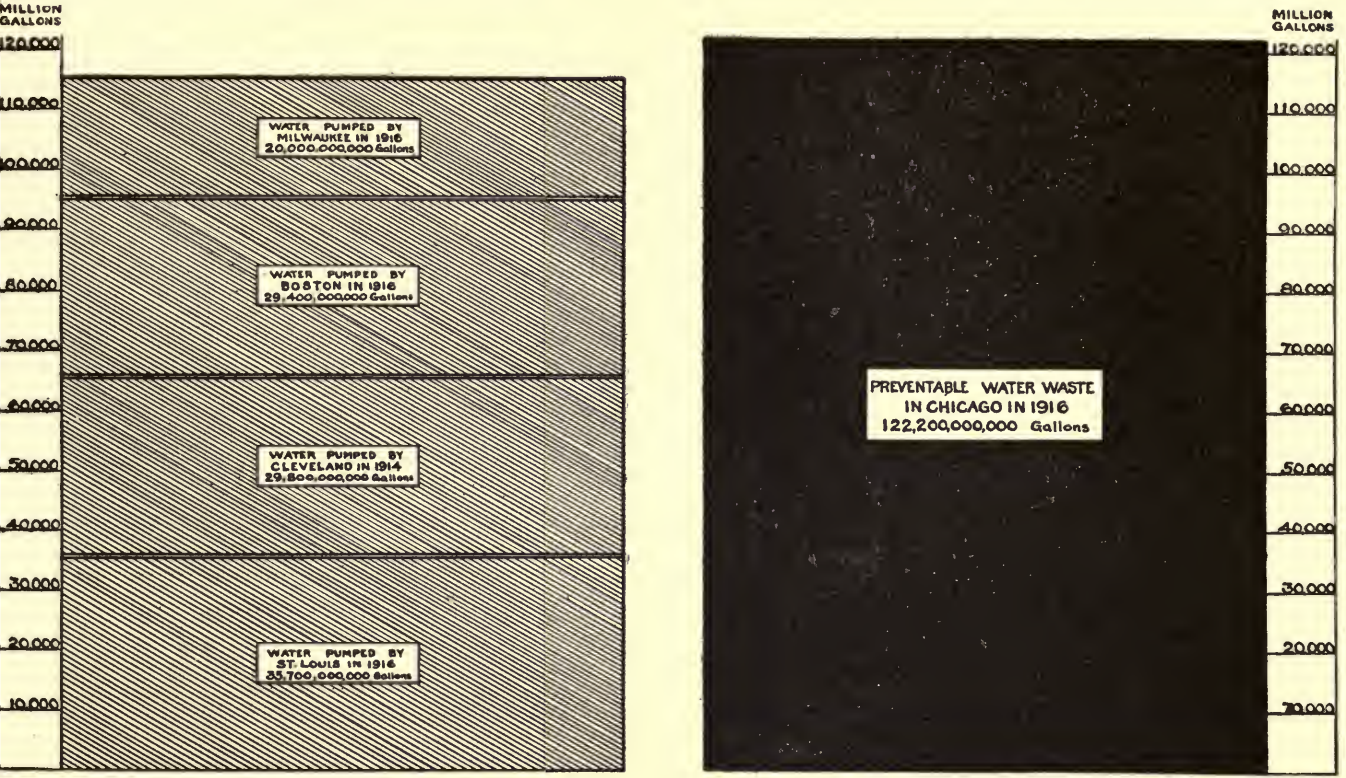
Waste and Leakage on Premises

Waste and leakage on consumers' premises, the principal causes of which have been heretofore indicated (page 129), can be practically eliminated. The number of people who wilfully waste water and who permit it to leak away through defective plumbing pipes and fixtures is very large. Each consumer feels that the amount of water lost on his premises is so small as not seriously to affect the amount pumped and therefore often makes little or no effort to check the waste and the leaks so long as they do not interfere with his getting sufficient water for his needs. With many other consumers pursuing the same policy the aggregate loss becomes very great.

Wilful waste should of course be checked, and leakage from defective plumbing should be stopped by requiring consumers to keep their plumbing and fixtures in repair. Effecting these results so far as practicable is the essence of the waste problem as related to the premises of consumers.

Where premises are under effective waste control, the inconsequent waste and leakage which cannot be prevented may for practical purposes be regarded as a part of the water used, and therefore need not be taken into consideration in making an allowance for unpreventable waste and leakage.

CHICAGO'S PREVENTABLE WATER WASTE EXCEEDS THE COMBINED PUMPAGE (INCLUDING WASTE) OF MILWAUKEE, BOSTON, CLEVELAND, AND ST. LOUIS



Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

The Extent of Preventable Waste and Leakage

An allowance of 23 gallons for pump slippage and other losses in delivery and of 102 gallons for water used would necessitate an average daily pumpage of 125 gallons per capita. Such an allowance is considerably in excess of the pumpage of Milwaukee, Cleveland, and other cities under good waste control, and should provide an abundant supply for Chicago.

Inasmuch as the total daily pumpage in 1916 reached 259 gallons per capita, it must be plain that the preventable water waste and leakage in Chicago amounted to 134 gallons per capita per day, or more than half the total pumpage.

A daily per capita consumption of 134 gallons is equivalent to 330,000,000 gallons per day.

Chicago loses through preventable waste and leakage more water than the combined supply (including waste and leakage) of Milwaukee, Boston, Cleveland, and St. Louis.

Economic Loss Due to Waste

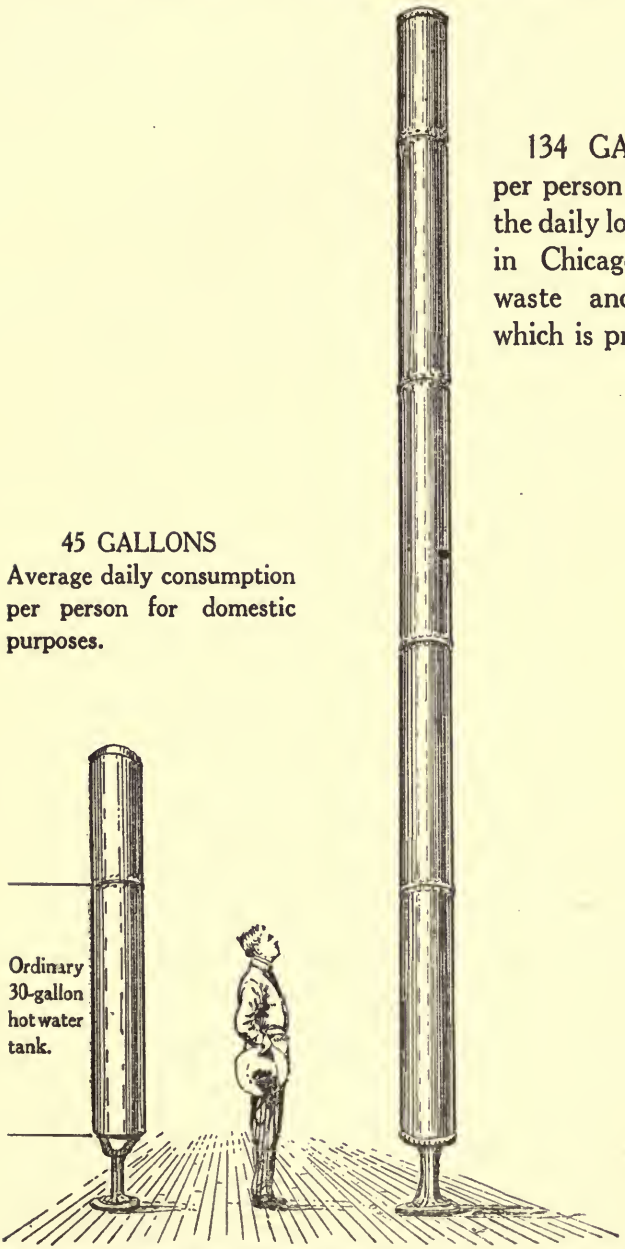
It is frequently said that there is an abundance of lake water which is free and that therefore it is a matter of indifference whether or not it is wasted. This is the present attitude of many consumers. True, *the water itself is free,* but the City is in the business of transporting it from the lake to the premises of the consumers and *its transportation costs money.* "It takes just as much coal, oil, waste, and equipment to pump water to waste into the sewers as it does to furnish water for a useful purpose."*

In 1916, the Chicago Water Works undertook to deliver daily to its consumers 645,000,000 gallons of water.

*Report, Philadelphia Bureau of Water, 1914.

134 GALLONS
per person represents the daily loss of water in Chicago through waste and leakage which is preventable.

45 GALLONS
Average daily consumption per person for domestic purposes.



AVERAGE DAILY CONSUMPTION OF WATER PER PERSON FOR DOMESTIC PURPOSES COMPARED WITH THE AMOUNT OF PREVENTABLE WASTE AND LEAKAGE IN THE CHICAGO SYSTEM

This was equivalent to the load of 1,300 sixty-car freight trains a day. More than half the freight was thrown away, however, either in the course of delivery or after it had reached the consumers.

In discussing this phase of the subject before the American Association of Engineers, Mr. John Ericson, the City Engineer, recently said:

> "One argument is that we have a lake with an inexhaustible supply of water right at our doors and that the water, therefore, should be as free as the air we breathe.
>
> "Sure, we have plenty of water in the lake. Anyone can go there and take all the water he desires, as they did in the earliest days of our city, but if you want to have the needed supply brought to your home under a high pressure it is a little different. As Mr. Saner puts it in a recent report to me on this subject: 'The same argument might be applied to sand. Anyone can go down to the lake shore and get a cubic yard of sand. No one will stop them, but still they will pay $1.75 to have this same yard of sand delivered to them; they pay for the labor and transportation.'
>
> "As regards water, it must be of a good quality. For this reason expensive tunnels extending miles out into the lake must be constructed to carry the pure water to the pumping stations. There are costly structures to protect the intakes. Complicated machinery and buildings to house same must be constructed. Thousands of miles of mains and services, with valves and hydrants, must be laid. Hundreds of tons of coal per day must be burned in order to obtain the necessary power to operate the pumps. Men for the designing, constructing, operating, maintaining, repairing, collecting of taxes, and for other purposes must be hired and paid. When considering that over one-half million dollars is expended each year for fuel alone for operating these pumps, it can be seen that a 50 per cent waste represents large sums of money lost, and that common business methods should be applied in conserving the water

supply, as is done in the case of other commodities. That is common sense. Who could conduct a successful business if he deliberately allowed over 50 per cent of the commodities he is selling to go to useless waste?''

Waste Impairs Service

How transporting the large body of water which is lost through waste and leakage overtaxes the pumping equipment and mains, increases friction and lowers pressures, thus seriously impairing the efficiency of the plant and frequently depriving consumers of uninterrupted and satisfactory service, has already been described. (See pages 112-114.)

Effect of Waste on the Development and Cost of the Plant

As heretofore pointed out (page 118), it was anticipated that the completion of the Central Park Avenue and Springfield Avenue pumping stations in 1901 would provide a plant with a pumping capacity sufficient for a population of 3,500,000.

These stations had scarcely been put into operation, however, before the City Engineer began to call attention to the shortage of water due to waste and to urge the need for eliminating it. The failure of the City Council to respond to these warnings and to adopt effective waste control measures made it necessary to commence work on further additions and improvements. Since 1901, 445 million gallons per day have been added to the rated pumping capacity of the plant—an increase of 88 per cent in fifteen years. During this time the population has increased but 40 per cent.

The plant today has a capacity sufficient to supply the requirements of at least five million people and yet the extensions now under construction and those proposed by

the City Engineer will, if built, practically double the present capacity within the next twenty years, at the expiration of which the population in all probability will not have reached that number.

In 1906-07, a twenty million gallon pump was installed at the Sixty-eighth Street station and a forty million gallon pump was added at the Central Park Avenue station and at the Springfield Avenue station. In 1911, two auxiliary pumps with a total capacity of fifty million gallons per day were erected at the Twenty-second Street station. In 1913, because of the need for reserve equipment, a twenty-five million gallon pump was placed in each of the four following stations—Fourteenth Street, Harrison Street, Central Park Avenue, and Springfield Avenue. In 1914, a twelve million gallon pump at the Sixty-eighth Street station was replaced by two centrifugal pumps with a total capacity of forty million gallons daily.

The necessity for the greater part of the additional equipment above enumerated can be attributed directly to the large amount of water lost through waste and leakage. This additional equipment does not include, however: (1) the rehabilitation of the Chicago Avenue station where the rated capacity of the pumps was not increased although the efficiency of the new pumps is much greater than that of the old pumps; or (2) the rehabilitation of the Lake View station where the rated capacity of the new pumps is fifty-five million gallons per day greater than that of the old pumps; or (3) the replacement, temporarily and until a new station can be built, of several old pumps at the Sixty-eighth Street station with two new pumps of much greater efficiency; or (4) the addition of the Roseland station with its capacity of 100,000,000 gallons per day. The waste prob-

lem has also influenced plans for these stations as well as for the additional tunnel capacity and the additional boiler and other auxiliary equipment which has been necessary.

The extent to which the loss of water through waste and leakage has influenced the plans for plant extensions and the very large capital outlays involved therein is well illustrated by the designs of the Southwest Lake and Land tunnel and of the new Wilson Avenue tunnel.

The Southwest Lake and Land tunnel has a daily capacity of 400,000,000 gallons. It was designed to supply the Roseland pumping station and also two, or possibly three, other stations which have not as yet been constructed. Although it was completed in 1911, less than half its capacity is being utilized at present. This tunnel, together with the Sixty-eighth Street station tunnels, supplies water for practically all the territory south of Thirty-ninth Street, except the stockyards district which draws its supply for the most part from the Twenty-second Street station. The combined capacity of the Southwest Lake and Land tunnel and of the Sixty-eighth Street pumping station tunnels is 500,000,000 gallons per day which is sufficient for a population of approximately 4,000,000. In 1916, the population of the City within the territory which these tunnels now serve (and may be expected to serve in the future) was about 725,000. No attempt has been made to estimate at what date, if ever, a population of 4,000,000 may be expected within this territory, or how much of the capital outlay involved in the construction of the Southwest Lake and Land tunnel might have been saved but for the attempt of the Bureau of Engineering to anticipate future demands based upon the assumption that the present rate of waste and leakage would be continued or possibly increased.

The extent to which waste was taken into consideration in the planning of the Wilson Avenue tunnel is well stated in the annual report of the City Engineer for 1913 as follows:

> "The area to be supplied was assumed to be all of that part of the city lying north of Fullerton avenue. This district has at present—January 1, 1914—an area of about 48 square miles and a population of approximately 360,000. An assumption of an ultimate population of 40 people per acre or 25,600 people per square mile was made, which would equal 1,228,000 in the district and would be reached in 1940. A rate per capita of 300 gallons per day was taken as a basis for estimating the ultimate supply required, which would be 375,000,000 gallons per day.
>
> "A ten-foot tunnel would be sufficient for 25 years, and would cost approximately $900,000 less than a tunnel of the required capacity in 1940; $900,000 would be worth in 1939 at 3 per cent. compound interest, $1,881,000, which amount would not construct a tunnel which would probably be required at that time. The system was, therefore, designed for 350,000,000 gallons, which is practically the amount that will be needed in 1940."

But 36 of the 200 square miles within the present City limits have a population of 25,000 or more, so that an estimate of 25,600 per square mile for the territory above described would seem to be sufficiently liberal. This territory is used largely for residential purposes. For territory of this character a per capita consumption of 100 gallons per day would be a very liberal estimate and should furnish an abundant supply. Obviously, therefore, this tunnel is being constructed with three times the capacity which would be required of it but for the excessive per capita consumption upon which the plans were designed on the assumption that waste and leakage are to continue as in the past.

On the assumption that the tunnel as designed will be

required by 1940, the Bureau of Engineering estimates the capital outlay, which will not be called into use until that time, at $1,881,000. Of course the unnecessary capital outlay being made is very much greater than that amount if it be assumed that the tunnel is designed to supply three times the quantity of water which the ultimate demand upon it should require.

Besides increasing the tunnel and pumping capacity of the plant, it has been necessary to make extensive additions to the distribution system. Many of the mains laid, especially the large feeder mains for the construction of which approximately $3,500,000 have been expended within the past five years, are entirely unneeded except for the purpose of transporting water which is lost through waste and leakage.

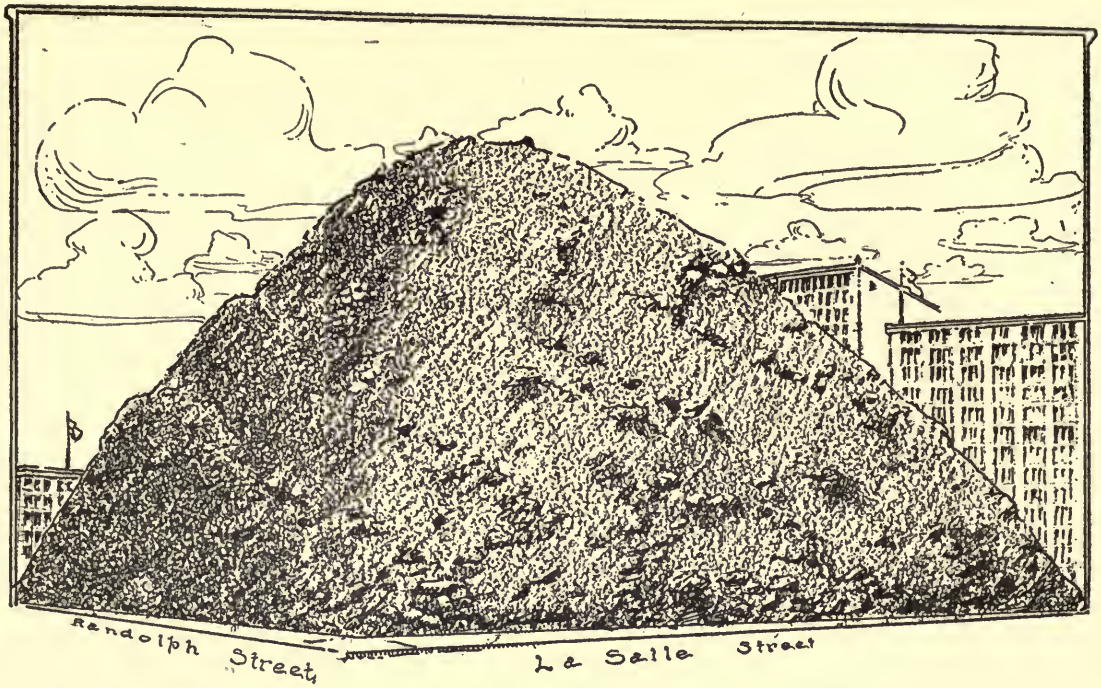
The original cost of the water works plant December 31, 1901, as reported by the Department of Public Works, was $34,061,076.98; December 31, 1916, it was $70,773,556.12—an increase of 107 per cent in fifteen years. The cost due to extensions and additions increased approximately 65 per cent; the population, about 40 per cent. Expenditures for replacements increased the cost about 15 per cent; those for plant and equipment not directly involved in the furnishing of water, including the intercepting sewer system and the new municipal shops, about 27 per cent.

For many years the revenue derived from the sale of water has been about double the amount required for the expense of operation and maintenance, but the excess, large as it has been, has not been entirely sufficient to meet the extraordinary demands upon the water fund, among them the expenditure of millions of dollars for the tunnels, pumps, and mains necessary to supply water lost through waste and leakage, which enormous as it was

fifteen years ago has since increased faster than the population. In recent years general taxation has been resorted to to meet payments on water works bonds, and during the present year it has been necessary to anticipate future income by issuing water certificates in order to complete improvements under construction. The extensive additions to the plant, necessitated by the constantly increasing volume of waste, have contributed largely to this situation.

Effect of Waste on Cost of Operation and Maintenance

The total cost of operating the water works plant for the five-year period ended December 31, 1916, as reported by the Commissioner of Public Works, was $10,087,834. Of this amount $4,779,077, or nearly half, was expended for the operation of pumping stations—in other words, for pumping water which is often regarded as free. The largest items of expense in pumping station operation are salaries, wages, and fuel. Expenditures in 1916 for salaries and wages amounted to $433,702.65; expenditures for fuel and power amounted to $444,284.94, making a total of $877,987.59. Approximately half the fuel and power consumed was used to pump water that was lost because of waste and leakage which could have been prevented. Plainly, therefore, in 1916 waste and leakage which could have been eliminated without restricting the use of water cost the City about $220,000 for fuel and power. A similar condition has prevailed for several years. Waste and leakage also make it necessary to operate and maintain a larger number of pumps and boilers than would otherwise be required, thereby increasing the cost of pumping station labor, supplies, and repairs. The additional annual cost for these last three items probably aggregates more than $230,000. Thus it has been costing



ONE YEAR'S COAL SUPPLY FOR THE CHICAGO WATER WORKS

In 1916, 190,000 tons of coal, costing $450,000, were consumed by the Chicago Water Works. This coal, one-half of which was used in pumping water which did no one any good because it was lost through waste and leakage, would have made a pile 196 feet high covering the square block bounded by Randolph, Clark, Washington, and LaSalle Streets.

nearly $500,000 a year, or about one-half the entire cost of operating and maintaining the pumping stations, to pump water which is later wasted or which leaks away and serves no useful purpose of any kind. With the cost of coal advancing and the volume of waste and leakage increasing, operating costs will of course be more seriously affected. From the standpoint of the money saving which could be effected, it is therefore becoming increasingly important to eliminate waste. Moreover, in view of the problems now involved in mining and transporting coal and of the resulting need for conserving its use, the necessity for preventing water waste, and hence fuel waste, is becoming more and more urgent.

Effect of Waste on the Cost of Filtration

If Chicago shall ultimately decide to filter its water supply, the amount of water wasted will have an important bearing upon the cost and other problems involved in carrying out the plans.

The cost of constructing and operating filtration plants is in direct proportion to the quantity of water filtered. To construct plants for filtering the *water now being wasted* would require $6,600,000. This is on a basis of $20,000 per million gallons per day of water filtered, a figure recently used by the City Engineer in discussing the subject. To operate these plants would cost approximately $600,000 per year. If the present policy of permitting practically unrestricted waste and leakage is continued, the volume of water lost through these sources will be greater in the future than at present. Accordingly, when the time finally arrives for building filtration plants, the amounts which will be involved in filtering waste water will be much larger even than those here mentioned.

Waste as Related to Sewage Disposal

Chicago is now discharging its sewage and industrial wastes into the Chicago River and the Sanitary District Canal, where they are diluted with lake water and carried off into the Desplaines and Illinois Rivers. This method has not proved altogether adequate. The ultimate solution of the sewage disposal problem will probably be found in supplementing the dilution method with plants for the purification of the sewage to some extent before it is discharged into the drainage canal.

If such sewage disposal plants shall later be found necessary, the cost of constructing and operating them will be affected by the amount of water which is mixed with the sewage to be treated. A large amount of waste water will mean a large volume of sewage mixture to dispose of, which will necessitate larger and more expensive disposal works than would otherwise be necessary.

Waste water, therefore, instead of being of value in helping to dispose of sewage by flushing the sewers (as it is sometimes erroneously thought to be by persons unfamiliar with conditions) will complicate and add to the expense of the problem whenever it shall become necessary to operate disposal plants. To flush a sewer effectively requires a large volume of water concentrated upon the section of the sewer to be flushed. While the aggregate volume of water lost through waste and leakage is enormous, it is so spread out over the city as to be entirely ineffective for sewer flushing purposes. It should be borne in mind also that a considerable part of the water lost escapes through the ground and does not enter the sewers.

VI. THE REDUCTION OF WATER WASTE

It may be safely asserted that the Chicago Water Works will never furnish satisfactory and economical service until waste and leakage are reduced to within reasonable limits. Any attempt to overcome their ruinous effects upon service by adding more pumps will prove a hopeless race with leaky pipes and the open faucet and will result in the further waste of public funds on a large scale.

Waste and leakage have been steadily increasing for many years and experience indicates that they will continue to increase unless effective measures are taken to check them. Efforts to offset the constantly growing loss of water by providing additional equipment have resulted in the pumpage increasing more than twice as fast as the population during the past fifteen years. But these efforts have been only partially successful in improving conditions with respect to service, while the large expenditures involved for both construction and operating purposes have practically bankrupted the water fund. There is nothing to warrant the assumption that similar efforts in the future will be more effective or less expensive. On the other hand, if waste and leakage are eliminated so far as practicable, there will be no difficulty in furnishing adequate service at a very large saving in operating costs and with a greatly reduced outlay for additional plant and equipment which otherwise will be required.

The reduction of water waste and leakage is therefore a matter of vital importance from the standpoint of both efficiency and economy.

In this connection, it should again be emphasized that the reduction or elimination of waste and leakage does

not mean the restriction of any person in the "use" of all the water he can use or is accustomed to use. Water can be supplied so cheaply in Chicago that the City can have no incentive to curtail its "use" in any manner. What is desired is to stop the necessity for pumping and distributing an enormous volume of water which is of no "use" to anyone.

Efforts to reduce waste and leakage should, of course, be directed against losses both in delivery and on the premises of consumers.

REDUCING LOSSES IN DELIVERY

Losses in delivery due to pump slippage can be kept within reasonable limits as heretofore indicated, provided sufficient reserve equipment is maintained to permit taking pumps out of service and making necessary repairs when the slippage becomes excessive.

Excessive under-registration of meters can also be avoided by a system of periodic tests, supplemented by necessary repairs. Such testing is essential, however, if substantial losses which otherwise will result from defective meters are to be avoided.

The most serious losses in delivery are due to breaks and leaks in the mains and service pipes, and the matter of reducing and holding them to a practicable minimum presents a serious problem. Its satisfactory solution calls for a systematic and continuous survey of the entire distribution system so as to locate important underground leakage, the survey to be supplemented by such repairs as the conditions disclosed may require or warrant.

Beginning about ten years ago the Bureau of Engineering conducted water waste surveys over a considerable

area of the City, accompanying them with the rehabilitation of some of the lines surveyed. In this work the engineers were seriously handicapped in obtaining definite data as to underground leakage because they were unable in most cases to isolate the main from the premises of all consumers, by shutting off the curb cocks on the service pipes, and then, by measuring the flow of water into the isolated main, to determine definitely the amount of leakage therein. Neglect and disuse of the curb cocks and buffalo boxes have become so general that a large percentage of them must be located by digging and then must be put in repair before they can be operated.

Within the last few years the policy with respect to waste surveys has changed and they have been confined largely to streets about to be paved. From seventy-five to one hundred and fifty miles of mains are now being examined and repaired annually under this plan, depending upon the amount of paving undertaken.

The work now being done involves the location and repair of buffalo boxes and curb cocks so that they may be closed and the mains accurately tested for leakage, after which both mains and service pipes are rehabilitated and repaired so far as necessary in order to reduce leakage therein to the lowest practicable amount.

The work of locating and checking leakage in the distribution system should be extended as rapidly as possible and, in connection with any general extension of the meter system, should be pushed to keep pace with the latter. Conditions existing just prior to street paving are particularly favorable for work of this kind because the mains may be reached and made tight without cutting through any pavement. Survey and rehabilitation work such as should accompany metering would in all proba-

bility require the preliminary repairs necessary to the making of accurate tests for leakage. The extent and thoroughness of subsequent repairs, particularly on mains under paved streets, would, of course, have to be determined in each case in the light of the conditions disclosed by the test.

Past surveys and investigations indicate that the leakage from service pipes aggregates an enormous total. Thousands of these pipes have been connected with the mains and run to the curb lines opposite vacant lots, but have never been used either because the property is still unimproved or because, when improvements were made, it was found that the pipes thus laid were not needed, or that they were not in the right location or of proper size. Many of these unused services have broken off at the mains, have opened up under pressure, or are leaking badly at the curb cocks, thus wasting large quantities of water.*

Of recent years the laying of services in anticipation of future use has not been so general as in former times and at present the practice is confined largely to streets about to be paved, the purpose being to avoid so far as possible the subsequent opening up of pavements to make connections. The Bureau appreciates the reluctance of property owners to have pavements opened up after they are laid but in view of the conditions above described, it may be seriously questioned whether the present practice should be continued. In commenting on this matter in his annual report for 1911 the City Engineer said:

> "Fifty-five per cent of the service pipes laid and connected to the mains in 1911 were for future use. These were laid prior to street paving and the water is turned on to the shut-off at the curb. It is probable that a large proportion of this 55 per cent will

*See page 133.

never be used, but will remain as a source of leaks and a positive detriment to the pavements, which have to be opened to repair leaks in these very pipes that were laid to prevent such openings.

"In my opinion, the custom of laying service pipes in streets to be paved should be adhered to only when there is a probability of such pipes being used within two or three years. In many instances the pipe may otherwise never be used. It may not be in the right location or of the proper size to meet future requirements. An opening in a pavement two or three years old, with proper care, can be restored to a condition as good as the rest of the street. Any water stub not used is a financial burden on the property-owner, as no benefit is derived therefrom."

The present procedure of the City as to water services is to endeavor to have owners install such pipes in advance of street paving and, where the owner refuses to do so, to institute special assessment proceedings and make the installations thereunder. It would seem that most owners, if they intended to improve vacant property within a few years and could anticipate approximately the nature of the use to which it would be put, would see the economy of laying water service pipes before the street was paved and would voluntarily make the installations. The Bureau believes that when property owners are not willing to do this it is a mistake for the City to resort to enforced installations, and further that voluntary installations opposite vacant property should be permitted only immediately in advance of paving. Of course, in all cases mains should be laid before a street is paved.

METHODS OF REDUCING LOSSES ON CONSUMERS' PREMISES

So far as losses within the consumers' premises are concerned, they can be greatly reduced or substantially eliminated depending upon the method employed to effect the result. Practically there are but two methods for

controlling losses of this sort; one is by frequent house-to-house inspections accompanied by the rigid enforcement of penalties; the other is by the installation of meters.

HOUSE-TO-HOUSE INSPECTIONS

House-to-house inspections as a means of controlling waste and leakage are unsatisfactory in several respects.

Inspections Not Completely Effective

In the first place inspections are never completely effective in checking waste, although they may do much toward reducing the loss from leaky and defective plumbing. There are several reasons for this.

Inspections do not affect to any considerable extent the losses due to careless or wilful waste. In fact, inspection may not reveal this kind of waste because it is intermittent and either does not exist or is discontinued at the time the inspector calls to examine the premises. Moreover, the consumer who carelessly or wilfully wastes water, even if detected by the inspector, will in most cases resume his wasteful tactics immediately after inspection, which therefore has accomplished practically nothing. This applies particularly to consumers who deliberately waste water through the open faucet, the hose, the hopper closet,* and other flushing devices.

*The so-called long hopper closet is perhaps the most wasteful sanitary device in use. It is described as "a sanitary device, used for water closet purposes. It costs less to install than closets with flush tanks and can also be used outside or in basements where a moderate amount of freezing will occur. The various controlling devices used to regulate the [water] supply for hoppers are inexpensive fixtures and are apt to get out of order easily. In addition, a part of the device is under cover and difficult to get at, so that maintaining them in good order is a burden to the consumer." (Report, Department of Public Works, 1911.) Quite generally the water is allowed to run continuously in these closets and tests show that when this is permitted a single closet will waste from 6,000 to 10,000 gallons of water a day. Definite information is lacking but it is estimated that there are from 40,000 to 50,000 of these closets still in use, mostly in the older sections of the City.

Neither do inspections as a rule detect and check leakage immediately. Unfortunately, premises where no leakage occurs one day may be among the worst offenders the next and, since the consumer has no incentive to make the necessary repairs immediately, a large amount of water may be lost before the next inspection is made and the leaks detected. Theoretically, such losses may be reduced to a minimum by increasing the frequency of the inspections. Practically, however, the cost of inspections places a limit upon the number which can profitably be made. Hence under the most effective inspection system practicable a considerable amount of preventable leakage is certain to exist.

The effectiveness of the inspection method even within the limits of its practical possibilities depends in part upon the competency and integrity of the inspectors, the thoroughness with which they do their work, and the vigor with which they enforce orders to make repairs on premises where leaks are found. Incompetency or lack of integrity may seriously impair the results, and the danger that wasteful consumers will obstruct and interfere with inspectors in the discharge of their duties, by the use of political pressure or otherwise, is constantly present.

Inspection Method Costly

The effectiveness of the inspection method also depends in part upon the frequency with which inspections are made. To obtain even reasonably satisfactory results, at least two complete inspections should be made each year, with additional inspections when leaks are found, in order to insure proper repairs being made. Inspections are expensive. Several years ago the Bureau of Engineering made a very large number of them in

connection with extensive water waste surveys then being carried on. This experience indicates that the average cost per inspection is slightly in excess of $1.00. On the basis of the number of inspections and re-inspections above indicated, the cost of maintaining the inspection system would be approximately the same as the cost of maintaining and reading meters. On the above basis, however, the inspection method would not be nearly so effective as the meter method. To attempt to increase the effectiveness of the inspection method through more frequent inspections would merely further increase its cost out of proportion to the results obtained, as compared with the results obtained from the meter method.

Inspections Produce Only Temporary Results

Another serious objection to the inspection method is that no permanent benefit is derived from the money expended upon it. The results which it produces last only so long as the inspections are continued. If for any reason inspections are relaxed, conditions revert almost immediately to their former state. This was demonstrated by the extensive experiments in the house-to-house inspection work conducted by the Bureau of Engineering several years ago, and is the experience of other cities that have tried this method. During the six-year period beginning with 1908, Chicago spent approximately $420,000 in water waste survey and inspection work. This work was of value in stopping considerable leakage temporarily and in providing data as to waste conditions. It is significant, however, that it did not effect any permanent results, and that waste and leakage have steadily increased as is indicated by the steadily increasing rate of consumption per capita.

To be even measurably successful, the inspection

method must be prosecuted vigorously and must be strongly backed by administrative officials; also it must be supported with funds necessary to carry on the work properly and must be continued perpetually. Any relaxation in the work of inspection will be followed by an immediate reversion to former wasteful conditions. Since changes in administrative officials and policies, such as frequently occur, or the withholding of adequate appropriations often result in inspections being relaxed or abandoned, attempts to effect waste control by this method seldom if ever accomplish lasting reforms.

Penalties Must be Enforced

The inspection system is generally burdensome and disagreeable to householders, and to be effective it must be accompanied by rigid enforcement of penalties against those who are found to be guilty of permitting waste and leakage. People do not like to have their houses inspected. When penalties are in fact enforced they are more burdensome and expensive to the shiftless and wasteful consumer than is metering, which is much more effective in preventing waste—the thing which officials and other consumers are primarily interested in. On the other hand, under the inspection system, the large number of householders and other careful consumers, who keep their plumbing in repair and are not wilful wasters and who find that metering neither restricts their "use" of water nor burdens their pocket-books, are required to submit periodically to the annoyance and inconvenience of having their premises inspected. This annoyance and inconvenience is, of course, entirely eliminated by the installation of meters.

METERING

The other method of controlling waste and leakage is by the installation of meters. This method is effective and economical. It produces permanent results. The Bureau believes that experience has shown it to be the only satisfactory and equitable way to cope with the waste problem.

Metering Effective, Permanent, and Economical

Many consumers either carelessly or wilfully waste water in various ways. Among the worst offenders of this class are those who let the water run continuously to prevent it from freezing during periods of extreme cold and for cooling purposes during hot weather; those who will not take the trouble to shut off the hose when it is not in use or not needed for sprinkling purposes; and those who permit a continuous flow in hopper closets* and other flushing devices. A much larger number of consumers permit leakage from plumbing pipes and fixtures. In the absence of metering there is no inducement to conserve the supply. Consumers feel that the waste and leakage on their individual premises is insignificant. They therefore often make no effort to avoid waste and quite generally pay little or no attention to leaks unless they cause inconvenience, interfere with the service, or result in property damage. If only a few consumers assumed this attitude, it would make little difference, but with a large number assuming it the results are disastrous both to service and to finances. Inspections and penalties are of value in remedying such conditions but, for the reasons heretofore explained, they are neither effective nor satisfactory. Under metering,

*See note, page 153.

on the other hand, each consumer pays for the water he wastes and there is a constant incentive for each to reduce to a minimum the amount of waste and leakage on his premises. A city inspector might call two or three times a year. He might not be thorough or careful in his inspection, or he might be deceived or interfered with in his work. A meter is on the job all the time and results in each consumer becoming his own inspector, anxious to detect and check leaks and to curtail waste. Metering therefore is an effective means of controlling and preventing waste and leakage.

Second only to the effectiveness of the results secured by metering is their permanency. Once meters have been installed, there is no danger of waste and leakage being resumed. Inspection never relaxes because of changing administrations or policies, but each consumer continues to watch his own premises, realizing that if he fails to do so he will have to pay the penalty of his own wasteful or shiftless conduct and that he cannot transfer the burden to his more careful neighbors.

Considering the more effective and permanent results secured at approximately the same cost as for house-to-house inspections, metering is of course by far the more economical method.

Metering the Equitable Way to Sell Water

Metering not only produces effective, permanent, and economical results in controlling waste and leakage, but it is the only equitable method of dealing with the waste problem and of selling water.

"Under the present system in Chicago one property owner who owns a new building with modern tight plumbing fixtures pays as much for the water he uses as does his neighbor in the same size building and lot, but with

old leaky fixtures on which he neglects to expend any money whatever for repairs, as he thinks there is no inducement for him to do so.

"One buys some ice to cool his eatables in the summer; the other cools them by letting the water run continuously. One after getting through sprinkling his lawn shuts off the water until the next time for sprinkling; the other hides the nozzle of his hose in a bush and lets the water run all day and night.

"And for these and other reasons four, yes, even ten, times as much water is supplied to his neighbor while the taxes paid to the city remain the same in both cases."*

Few will be found to contend that the consumer who uses a small quantity of water and the one who uses a much larger quantity should pay the same rate merely because they occupy buildings of the same width and height, which contain the same number of fixtures. It is even more unfair, however, that the consumer who keeps his plumbing in good repair and is careful to avoid waste should bear any part of the expense caused by the wasteful or careless habits of his neighbor. Charging for water on the flat rate or frontage basis, such as is in effect for the most part in Chicago, produces results of this kind in thousands of cases.

Under the flat rate system the wasteful consumer does not pay the charges on what he throws away but makes the City collect them pro rata from all careful consumers in addition to the legitimate charges against the latter. Under metering, each consumer pays for the water he uses or wastes and no more. This is the only fair and equitable way to adjust charges.

*Extract from paper read before the American Association of Engineers, April 5, 1917, by Mr. John Ericson, City Engineer.

Selling water on a flat rate basis is about as business-like and fair as selling milk or meat or groceries or clothing at so much a month or a year and charging different families the same rate without regard to the number of members in each or the varying amounts which they might use or waste. It is as though a baker should sell unlimited bread per family at so much per year. Those who took five or ten loaves a day and threw most of it away would have their waste paid for by the vast majority of those who got on reasonably with one or two loaves a day for the family. No one thinks of buying such commodities as gas or electricity or street car transportation on any such arrangement and no one should expect to buy water that way.

Popular Objection to Metering

Notwithstanding the obvious advantages of metering as a means of controlling waste and of apportioning water charges, there is a strong popular objection to the installation of meters. This is true of Chicago and it is true of practically every other city where metering has not been adopted. It is significant however that cities where meters have been introduced have not gone back to former methods, the meters having proved satisfactory to both the municipality and the consumers. Milwaukee and Cleveland are typical examples.

It is a matter of common experience also that the most strenuous objections to the introduction of meters come from the larger cities. This is due principally to the fact that in such cities there is a larger proportion of tenant consumers, and that the landlords, who in a large number of cases pay the water charges, fear that their bills will be increased by the wasteful and careless practices of their tenants. That this fear is not well founded will be pointed out later.

The opposition to metering is due largely to prejudice and to a misapprehension as to the results which follow the installation of meters. There is a generally prevalent belief that meters are intended to restrict the "use" of water and that, unless the consumer cuts down the quantity of water which he requires or is accustomed to use, his water bills will be increased. The problem, therefore, is to overcome this prejudice and misapprehension by demonstrating that meters do not restrict the "use" of water; that they produce results by preventing waste and leakage; and that they result in an equitable apportionment of water charges, and in the reduction rather than in the increase of bills in the vast majority of cases. If consumers and owners can be convinced of these facts, opposition to metering will disappear. The same arguments that are advanced against meters today have been used for years not only in Chicago but in practically every other city where metering has been proposed. Yet wherever it has been introduced experience has demonstrated that there was and is no basis for the objections raised.

Meters Do Not Restrict "Use" of Water

Metering is not proposed as a means of restricting the "use" of water. "Use," we repeat, is meant to include every legitimate use to which water can be put for domestic, industrial, and municipal purposes, including water for sprinkling streets and lawns, extinguishing fires, flushing sewers, and every other purpose for which water is necessary or has any real value. The abundant use of water should be encouraged and every inducement should be held out, particularly to domestic consumers, to insure their using all the water which can possibly be of value in improving health and sanitary conditions. To

this end, rates should be fixed so as to guarantee every consumer an ample supply at a reasonable price which he should be required to pay even though he fail to use his full allowance. A minimum charge of this kind would remove any inducement to "skimp" or save on water at the expense of health or comfort and, as hereafter pointed out, would serve other important purposes.

One reason why metering is advocated is because it is the most effective means for insuring an abundant supply of water under sufficient pressure to enable all consumers, including those living in sections remote from pumping stations and upon the upper floors of apartment buildings, to obtain promptly and at all times the water which they require and are entitled to for their legitimate uses. This would be accomplished by curtailing waste and leakage and not by restricting "use." Such a condition has never existed in Chicago and in the opinion of the Bureau never will be brought about until metering is introduced on a comprehensive scale.

Meters are not intended to operate as a restriction upon the "use" of water and they do not in fact produce that result. This is well illustrated by the situation in Cleveland, Ohio, and in Oak Park, Illinois, both of which are under complete meter control.

Both Cleveland and Oak Park charge on the basis of a certain rate per thousand gallons but fix a minimum charge which must be paid whether or not the quantity of water to which the consumer is entitled for that charge is used.

In Cleveland, the minimum charge applicable to the large majority of consumers is $2.50 or $5.00 a year, depending upon the size of the building, the number of fixtures, etc. For these amounts consumers are entitled to 46,875 and 93,750 gallons, respectively. For the six

months period ended September 30, 1915, there were 27,374 consumers liable to pay at the $2.50 rate and 60,393 liable to pay at the $5.00 rate regardless of whether or not they used the full amount of water to which they were entitled under those rates. Of the 27,374 subject to the $2.50 rate, 18,141, or 66 per cent, used less water than they were entitled to and paid for; of the 60,393 subject to the $5.00 rate, 35,481, or 58 per cent, used less water than they were entitled to and paid for, and 12,814 used less than half that amount. These figures cover the summer period when the consumption was heaviest on account of the use of water for sprinkling purposes and on account of such use as may have been made of it for cooling purposes. During the winter period even a larger number of consumers failed to use the amount to which they were entitled for the minimum charge. The Bureau does not mean to be understood as expressing any opinion as to the reasonableness of the charges here cited. The purpose in citing them is merely to show that when consumers are required to pay a relatively small minimum charge—one smaller than the flat rate charge made in thousands of cases in Chicago—they are unable to "use" all the water that such a minimum charge will buy.

In Oak Park, the minimum charge is $7.00 per year for which the consumer is entitled to 36,000 gallons. The accounts for a recent year show that of 4,546 residential consumers subject to this minimum charge 941, or 21 per cent, used less water than they were entitled to and paid for.

At the minimum rates above mentioned there could be no possible incentive for anyone to restrict his use of water, and certainly it is not to be inferred that the people of either Cleveland or Oak Park have lower stand-

ards of cleanliness than the people of other communities, or that they require less water for their legitimate uses.

Metering produces results not by restricting usage, but by preventing waste and leakage. When a consumer knows that he will have to pay for the water that he wastes, he is careful to avoid wastage. He no longer installs fixtures of a cheap and wasteful type, such as hopper closets, or permits minor leaks, which can be readily repaired at trifling expense, to continue indefinitely; he protects his pipes from freezing so that there is no occasion to let the water run continuously during cold weather and he shuts off the hose when he is through using it for sprinkling purposes; he avoids leaving the faucet open when not using water; and in countless other ways is careful to prevent waste. With practically every other consumer exercising this care to eliminate waste, water can be furnished so cheaply that no one need think of restricting the amount which he can make any use of.

Keeping plumbing tight and shutting off the water when it is not in use are the important factors in effecting waste control, and there is nothing unfair or harsh in the suggestion that water users be required either to observe these precautions or to pay the penalty of their own shiftlessness and carelessness. Experience shows that about half the people who use water are not wasteful or shiftless. The exercise of reasonable care in matters related to the water supply, as in other things, becomes a habit with them and imposes no hardship. It is manifestly unfair therefore to permit the other half who are wasteful to saddle the expense of their carelessness and shiftlessness upon their more careful neighbors. If consumers insist upon wasting water, either wilfully or by permitting their plumbing to remain continuously out of repair or by installing cheap and wasteful fixtures, they

should be required to pay for what they waste. Under metering they do pay for it. The result is that they soon find it profitable to stop the waste.

A very large amount of water is wasted by those consumers who permit it to run continuously in the winter to prevent its freezing and in the summer for cooling purposes. There is no excuse for permitting the open faucet as a means of preventing freezing. Property owners should be required to protect their pipes from frost.

The problem growing out of the use of water for cooling purposes is not so easily disposed of, however, since there is considerable public sentiment against restricting the practice, which prevails largely in those sections of the City tenanted by families too poor to provide themselves with ice. Lake water is not really effective as a means of refrigeration, and from the standpoint of the City, its wasteful use for such purpose is expensive. Probably it would be cheaper for the City to furnish the poor with ice than to permit a continuance of the waste which at present exists in this connection. Assuming, however, that in the absence of some better arrangement these poor families can make some legitimate use of water for cooling purposes, it may be safely asserted that they now waste more than they use in the process. Only a moderate quantity is required. A wide open faucet is no more effective than one permitting the continuous flow of a small stream. If proper care were taken to regulate the size of the stream, all the water which a family could use by letting it run continuously four months of the year would not cost to exceed $2.00. Moreover, in many cases the minimum charge which a consumer should be required to pay would entitle him to all the water used in this way, in addition to that used for other purposes. In such

cases, of course, the use of water for cooling purposes would not impose any additional financial burden upon the user.

It is sometimes urged that the excessive amount of waste and leakage in Chicago tends to help in the matter of sanitation. This is due entirely to a misunderstanding of the facts. Waste reduction measures do not aim to curtail the abundance of water which is essential to cleanliness and proper sanitary conditions. Their purpose is to cut down the enormous quantity of water which runs away through sewers and the ground without serving any useful purpose whatever. Attention has already been called (page 147) to the uselessness of water waste as a sewer flushing agency.

Meters and Their Effect Upon Water Bills

Another reason why meters are opposed is the belief that they operate to increase water bills. This belief prevails quite generally *where meters have not been introduced.* The consumer who pays his own bill feels that in order to avoid increased cost he will have to cut down the amount of water which he needs or has been accustomed to use. The landlord who pays the charges for the water used by his tenant fears that he will be robbed by the wastefulness of the latter, who will have no incentive to avoid waste. Each therefore is opposed to meters. Moreover, the landlord, in addition to exerting his own influence against them, by threats of increasing rents or otherwise, often persuades his tenant to oppose them. The opposition to meters accordingly becomes general.

Opposition to metering on this ground is due entirely to a misapprehension as to the effect of meters upon charges. The experience of other places shows that

where rates are properly adjusted meters impose no added financial burden. With their installation on a large scale in Chicago, it should be possible to reduce present charges somewhat because of the reduction in waste and leakage which they will effect and the consequent smaller amount of revenue that will be required for operation, maintenance, and plant extension purposes.

Selling water by measure operates to equalize charges and in the process some consumers, who are large water users and who, on the flat rate basis, do not pay for as much as they take, find their bills increased. The vast majority of consumers are not affected in that way, however. The fact that some consumers who are large users would have their charges increased constitutes no valid objection to metering. Charges should be in proportion to the quantity consumed and if, under the flat rate system, some consumers pay less than they should for what they take, that is a sound reason for introducing the meter system which will require them to pay their due proportion.

Perhaps the most effective way to meet the objection that meters increase the cost of water to the consumer is to compare flat rate charges in Chicago with charges in other places where meters are in general use. The number of such places might be multiplied, but Cleveland, Ohio, and Milwaukee, Wisconsin, furnish excellent material for comparison because they are large lake cities having conditions of supply and consumption similar to those of Chicago. Oak Park, Illinois, and those Chicago residential consumers who are provided with meters also furnish interesting data.

Chicago rates vary according to the size of the building, the number of fixtures, the number of occupants and other conditions. No classification of consumers according to

the various amounts actually paid is available. For small one-story houses the charge ranges from $1.88 to $4.50 a year.* A one-family residence 21 to 24 feet in width and two stories in height having not to exceed one complete set of four fixtures is charged $5.64 a year; if a hose is used the charge is $7.14. This would cover any small house or cottage having two finished rooms on the second floor and is typical of what thousands of small property owners are charged.

An ordinary two-flat or apartment building having two complete sets of fixtures is charged $10.88 a year; if a hose is used the charge is $12.38. Larger buildings or additional fixtures of course result in higher rates.

Cleveland sells water for 5⅓ cents per 1,000 gallons, with a minimum charge of $2.50 or $5.00 a year (depending upon the size of the building, etc.) applicable to the large majority of consumers, who are entitled to receive therefor 46,875 and 93,750 gallons, respectively. For all water used in excess of those quantities the regular rate of 5⅓ cents per 1,000 gallons is charged. For the year ended September 30, 1915, the total number of consumers averaged 92,227. Of this number approximately 61,000, or 66 per cent, paid $5.00 or less; approximately 18,000 of these paid only $2.50. That these people did not find it necessary to restrict in any way their use of water is indicated by the fact that nearly nine-tenths of them did not use all the water they were entitled to for these minimum charges.

The Milwaukee rate is six cents per 1,000 gallons with no minimum charge. In 1916 there were 62,592 consumers. Of this number 30,258, or 48 per cent, paid less than $3.00 for their year's supply; 15,616, or 25 per cent, paid

*The amounts here used are the net charges after the discount of 25 per cent, which is allowed for prompt payment, has been deducted.

between $3.00 and $5.00; and 11,316, or 18 per cent, paid between $5.00 and $10.00. Thus nine-tenths of the Milwaukee consumers paid less than $10.00 a year for their water and three-fourths of them paid less than $5.00.

Oak Park figures are interesting because they show that under a meter rate such as prevails in Chicago* (6¼ cents per 1,000 gallons) very low charges may be expected even in a high class residence community, the people of which "use" water lavishly. In Oak Park of course waste and leakage are under effective control.

The records show that approximately 95 per cent of Oak Park consumers would pay less than $10.00 per year at the Chicago meter rate of 6¼ cents per 1,000 gallons; and that 75 per cent would pay less than $5.00 per year. Oak Park is almost exclusively a residence community. An examination of the accounts made by the Bureau showed that, of 5,403 premises supplied with water for a full year, 4,546 were residences and 453 were apartment buildings; also that the average charge for residences at the Chicago meter rate would have been $4.04 per year and that the average charge per apartment building would have been $8.34 per year. These figures should be particularly interesting to Chicago property owners who are paying substantially double these amounts for the same kind of water in the same class of buildings.

In the sections of Chicago known as Austin and Morgan Park, there are still in service in residences and two-

*The Village of Oak Park purchases its water supply from Chicago at the regular meter rate of 6¼ cents per thousand gallons and resells it to consumers at from 18 to 15 cents per thousand gallons. The water is delivered to the Village by the City under a pressure of from 15 to 25 pounds and is repumped by the Village and delivered to its consumers under a pressure of from 35 to 45 pounds. The Village maintains and operates its own pumping station, distribution system, and meters, and makes its own collections from consumers. The 18-15 cent rate is made to cover the cost of these items and also to provide an amortization fund, the plant having been purchased from a private company only a few years ago.

apartment buildings a large number of meters which were installed prior to the annexation of those sections to the City. A similar situation exists in Rogers Park although the number of meters is smaller. An examination of the accounts covering 800 such premises in Austin, 500 in Morgan Park, and 200 in Rogers Park showed that the average charge per residence in Austin is about $4.50 a year; in Morgan Park, $4.00; and in Rogers Park, $6.70. More than half of the residential consumers of Austin and Morgan Park pay less than $4.00 a year; in fact about one-third of them pay less than $3.00. The higher charge in Rogers Park is probably due to the residences on the whole being larger and also to the more extensive use of water for sprinkling large lawns. The accounts covering 100 two-apartment buildings in Austin showed the average charge for that class of building to be $5.70.

The foregoing figures show clearly that the consumer who keeps his plumbing in repair and is careful to avoid waste may take all the water that he can make any use of without fear of having his charges increased by a change from the flat rate to the meter method of selling water. The figures show also that the ordinary residence and small apartment house owners in Chicago, who are careful about waste and leakage and who are charged on the flat rate basis, are paying too much for the water that they take. The careful consumers, under the flat rate plan, are paying not only for the water which they require, but for a proportionate part of all the water thrown away by the shiftless and wasteful consumers. Under universal metering, the careful consumer would be rewarded not only with improved service, but with lower charges, while the wasteful consumer would either have to eliminate the waste and leakage on his premises or pay for it—an obviously fair and equitable arrangement.

So far as the danger of landlords being robbed by the wasteful habits of their tenants is concerned, the Bureau believes that it does not exist to any considerable extent. The experience of other cities where metering is in effect shows that the number of tenants who wilfully waste water is not large. It has been said that the proportion of such tenants is probably not larger than the proportion of landlords who steal water from the city by illegal connections with the mains. Much of the waste ordinarily attributed to tenants is chargeable to careless landlords who neglect to keep their plumbing in order as required by the city ordinances.

The average number of consumers in Cleveland for the year ended September 30, 1915, was 92,227. The published statistics do not show what proportion of these were tenants. Of the total number, however, approximately 61,000, or 66 per cent, paid $5.00 or less for the year. An additional 24,571, or 26 per cent, paid from $5.00 to $16.00. Still 4,261 others, or a further 4½ per cent, paid from $16.00 to $40.00. We think that it may be safely assumed that this 96½ per cent of consumers who paid $40.00 a year or less included practically the entire tenant population and that a large majority of this population was included among those who paid the $5.00 minimum rate. For the purpose of comparison attention is called to the flat rate charged for an ordinary six apartment building in Chicago, which amounts to about $40.00 a year.

A similar situation exists in Milwaukee, where in 1916 97¾ per cent of the total number of consumers paid less than $40.00; 91 per cent, less than $10.00; and 73 per cent, less than $5.00.

An average charge of $8.34 (on the basis of the Chicago meter rate) in Oak Park for apartment buildings of all

sizes—including large as well as small—compares quite favorably with the Chicago flat rate charge of $12.38 for an ordinary two-flat building.

As previously pointed out, the average charge on 100 two-flat buildings under meter control in Austin was found to be $5.70 per year.

All the large Chicago apartment buildings are now metered, until recently a meter having been required on any premises on which the net assessment rate was $100 or more per year.* Many smaller apartment buildings have also been metered under previous ordinances requiring meters on premises on which the assessment was then less than $100. For the purpose of determining how landlords in Chicago might be affected by metering, the Bureau selected at random 100 such buildings of various sizes situated in different sections of the City, and made a comparison between the actual meter charges thereon and the charges that would have been assessed on the flat rate basis. It was found that the owners of 56 of these buildings profited by having meters and that 44 paid slightly more than they would have paid under the flat rate system. The aggregate revenue received by the City would have been about the same under either plan. The effect of metering on these premises was to insure waste prevention and to distribute equitably the cost of supplying water. That this test does not show a larger number of owners profiting substantially through metering and also an aggregate reduction in revenue received by the City is due to the fact that consumers in these larger apartment buildings, unlike the occupants of many smaller buildings, quite generally "use" enough water to make the meter charges approximate the flat rate

*An ordinance passed on June 25, 1917, reduced this maximum net flat rate to $30.00 per year, but has not been in effect long enough to affect materially the situation as it has existed for several years.

charges. The figures show however that a majority at least of these landlords were not penalized by the wilful waste of their tenants, while the meters were undoubtedly of advantage to the City in that they made it an object for the landlords to avoid the waste due to leaky plumbing.

It is interesting to note in this connection that City officials report that owners of small apartment buildings, who are cognizant of the saving to be made through the installation of meters, frequently request them for buildings which under the ordinances are not required to be metered.

If all premises in Chicago were under meter control, a relatively small number of landlords, who under the flat rate method do not pay in proportion to what their tenants use, would probably have their water bills increased. A few also might be victimized by wasteful tenants. The Bureau is convinced, however, that the vast majority of property owners who keep their plumbing in order would benefit financially by the meter system.

Some protest against metering will probably be heard from those owners who now fail to keep their plumbing in repair in accordance with the requirements of the City ordinances and the practice of their more careful and conscientious neighbors. Of course, any system which permits a large portion of the property owners to take care of their plumbing but does not require the others to do so, permitting the latter to shift the burden of their neglect onto the former in the shape of increased water bills, is manifestly unfair on its face and such objectors are entitled to little consideration. However, considering that the life of plumbing repairs is estimated at from one to five years, even these shiftless landlords, who will protest against metering, will probably find

it more profitable to make the necessary repairs and pay for the water used than to continue paying the present, or possibly increased, flat rates.

Universal Metering Recommended

Partial metering, under which owners who are found to be wasteful of water are required to install meters, has been adopted in some cities and is sometimes suggested for Chicago. An ordinance passed by the City Council June 25, 1917, provides, among other things, that "meters may be installed upon service pipes found supplying leaks, waste or unauthorized, excessive or unusual use of water" and that at the discretion of the Commissioner of Public Works "said meters may be removed . . . . . when cause for installation is corrected." This ordinance is evidently designed to strike at the waste evil by the partial metering method. In the opinion of the Bureau any such policy will not meet the situation in Chicago and is not well advised. To be reasonably successful, partial metering must be accompanied by persistent house-to-house inspections for the purpose of locating leaks. It therefore has all the disadvantages of the house-to-house inspection method as a means of preventing waste, while it lacks the equitable features of universal metering under which each consumer pays in proportion to the water which he takes. Besides, it brings the meter to the consumer in the form of a penalty. This, as hereinafter explained, is repugnant to most people and results in increasing popular opposition to metering.

If the people of Chicago as a whole are to have adequate and satisfactory water service and if the millions of dollars which otherwise will be required for the future extension and operation of the water works plant are to

be saved, excessive waste and leakage must be permanently eliminated. Half-way measures will not accomplish this. No middle ground in the matter of waste reduction is likely to be found possible. Either waste and leakage will be permitted to continue practically without restriction as at present or they will be placed under effective control and reduced to a minimum. There can be no question as to which policy should be adopted, and experience shows that the only effective and permanent method of control is the placing of meters on the premises of all consumers.

The Bureau therefore recommends that the City authorities at once establish universal metering as a policy and take the necessary steps to put it into effect.

Plans for Putting Universal Metering into Effect

Assuming that universal metering is adopted as a policy, it probably will not be practicable to put it completely into effect in less than ten years. However, the work can and properly should be carried out within that time.

In carrying out the work all new buildings should be metered. There is substantial unanimity of opinion as to this. There are two reasons. In the first place, the cost of fitting water pipes with the necessary connections for the meter is negligible when the work is done at the time the pipes are being run into the building. When connections are made on old pipes considerable expense is involved because of the necessity for locating, digging up, and changing the piping. Secondly, the installation of meters on new buildings scattered throughout the City will help to build up public sentiment favorable to metering, since in practically all cases the owners of new buildings will profit by having meters.

As to the best plan to follow in placing meters on old buildings there may be differences of opinion. In general there are two ways in which to proceed. One is to select and meter first those consumers who use or are suspected of using proportionately more water than they pay for under the flat rate system, and also those who are found to permit waste and leakage. Under this plan the small and careful consumers would be metered last. The other way is to divide the City into districts and then, proceeding district by district, to place meters upon the premises of all consumers without discrimination.

The first plan mentioned, or selective metering, since it reaches principally the larger users (who profit by the flat rate) and the conspicuous wasters, operates (a) to increase the revenue derived from the sale of water and (b) to reduce waste and leakage more rapidly than does the district plan. For these reasons, selective metering commends itself to some. The ordinance passed on June 25, 1917, heretofore referred to, while it does not seek to establish universal metering, clearly embodies the idea that in extending the meter system it is desirable first to bring the large consumer and the wasteful consumer under meter control.

Neither increasing revenue nor eliminating immediately a large amount of waste and leakage is so important as insuring the effective and permanent solution of the waste problem. From this viewpoint and for other reasons, selective metering has distinct disadvantages.

Under the selective plan there is always danger of discrimination not only as between the individual consumers selected but as between the classes of consumers determined upon. In this connection, it is perhaps well to call attention to the fact that saloons have long been recognized as among the most extravagant and wasteful

users of water and the water authorities have therefore urged the need for placing them on a meter basis. Yet, when the ordinance of June 25, 1917, was passed, extending the meter system to other presumably large or wasteful consumers—many of them probably using or wasting less water than saloons—it did not include all saloons within its provisions.

There is a more serious objection to the selective plan, however. To the large user who has been profiting by the flat rate system a meter means increased charges. To the waster it comes in the form of a penalty and as a rule also means larger bills. It is of course entirely fair that large consumers shall pay proportionately for the water that they take and that the wasters shall be penalized. If these were the only considerations, selective metering would afford an admirable method. Its disadvantage lies in the fact that, in the beginning when the creation of friendly public sentiment is most important, practically every consumer for whom a meter has been installed finds his water bills increased and, therefore, becomes an active propagandist against metering. As a result, the thousands of consumers still without meters rapidly get the idea that metering will have the same effect in their cases, and join in opposing a further extension of the meter system. This idea quite naturally becomes prevalent, because the large mass of small and careful consumers, to whom meters would mean lower charges, have not had an opportunity to find this out for themselves. To invite such a situation in a community where a strong prejudice against meters already exists is bad tactics and may easily build up so much adverse public sentiment as to make it practically impossible to carry into effect a program for universal metering.

Metering by districts obviates the disadvantages just

mentioned. Under this plan the meter comes indiscriminately to every consumer as a just and equitable means of adjusting water charges. Incidentally, some large consumers will pay more and the wasters will be obliged to eliminate waste and leakage or to pay the penalty for its continuance. Some of these will protest but their protests will avail little against the sentiment created by the large majority of users who will avoid waste and keep their plumbing in repair and to whom metering will therefore mean better service and lower charges.

The tactical advantage of the district plan is that, while it may arouse the antagonism of a few, it at the same time operates to cultivate the favor of the many and thus, with continuously increasing effectiveness, to break down popular opposition until it ceases to be a matter of moment.

Other considerations which add to the desirability of the district plan are that by concentrating the work the cost of installing, maintaining, and reading meters can be greatly reduced and also that the general installation of meters within a district will be of material assistance in detecting and checking leaks in the distribution system in such district.

Everything possible should be done to make meters popular and the Bureau believes that when metering is undertaken on a comprehensive scale the district plan will produce the most satisfactory results. It is possible, however, that once the district plan has been established the principle of selective metering may be employed profitably to a very limited extent in coping with certain well-known classes of wasters.

Advantages of Plumbing Repairs Prior to Setting Meters

The installation of meters should be accompanied by the inspection of all premises to be metered, the owners of which should be required to put their plumbing in repair before the meters are set. If this is not done many owners will permit leakage on their premises to continue until they learn through largely increased water bills that leaks do not pay. The result will be that neither the City nor the owners will benefit to the extent that they should from metering, and that a great deal of dissatisfaction over the new system will spring up among owners. In a campaign not only to meter but to popularize metering an important advantage may be gained by protecting owners against their own ignorance and carelessness in the beginning, so that they may profit by having meters installed and hence become advocates of the new method. No additional authority would be required to enforce such repairs. The present ordinances, although as a rule not enforced, expressly forbid waste and leakage and authorize the Commissioner of Public Works to shut off the water from premises where leaks and waste are found.

Metering Should be Accompanied by Water Waste Surveys

Metering should be accompanied also by a systematic survey of the distribution system and such rehabilitation thereof as may be necessary to reduce leakage in the mains and service pipes so far as practicable. Otherwise, the better service and the economies which should result, from an aggressive waste reduction campaign will not be fully realized. Moreover, the inevitable disappointment which will follow will react against the further extension of the meter system.

Meters Should be Installed and Maintained by City

Meters should be owned by the City and should be installed and maintained as a part of the water works plant free of expense to consumers. This is the most efficient and economical plan to follow. An exception to the general rule should perhaps be made in the case of meters installed on lines supplying free water for fire or other emergency purposes.

Revenue Requirements and Water Rates

Future revenue requirements will depend in a large measure upon the policy which the City adopts relative to waste reduction. So long as the present policy is continued the demand for more water and better service may be expected to keep ahead of the efforts of water works officials to meet it. Under the insistent pressure of such a demand new tunnels, pumping stations, and other plant extensions will be started, in the future as in the past, as fast as projects under way are completed and funds can be found. Temporary relief, first for one and then another section of the City, will be afforded in this way, but under such conditions definite, intelligent, and economical planning for the future will be next to impossible. Revenue requirements will continue to grow and their limitations will be determined largely by what the traffic will bear. Present rates are not likely to be reduced and, if they do not produce sufficient revenue to build the necessary extensions, higher rates will have to be provided, as has recently been proposed.

From the standpoint of the economical administration of water works finances, it is essential that waste and leakage be reduced and kept under effective control, so that the plant requirements of future years may be fore-

cast with reasonable certainty and revenues and rates adjusted accordingly.

The control of waste through universal metering will effect an enormous ultimate saving in both operating and construction costs. The immediate saving, however, will not be so conspicuous.

For several years about half the water fund has been used for ordinary operating and maintenance expenses; the other half, for replacements and plant extensions. Since meter installations on old buildings will be gradual and will extend over a period of several years, no sudden decrease in expenditures and hence in the amount of revenue required for the operation and maintenance of the plant can be looked for. Metering will, however, operate to check the increase in expenditures which otherwise will necessarily be made for these purposes.

The effect of metering upon the amount of revenue required for plant extensions will be more immediate. The plant is now so far overbuilt for all legitimate needs that, if definite steps are taken to control waste and leakage effectively within ten years, the expenditures for additional tunnels, pumping machinery, and other requirements can be for the most part curtailed. This is one reason why it is important to adopt a policy of universal metering and to preserve its continuity, for until such a policy is definitely established water works officials will not be warranted in withdrawing projects designed to meet waste conditions which otherwise will have to be faced in the future.

During the period of meter installations the saving which can be effected in plant additions will be offset to some extent by the cost of purchasing and installing the meters. During the first two or three years after the policy of universal metering is established, an allow-

ance will also have to be made for funds necessary to complete projects already begun.

The rates now in effect will produce more revenue than will be required for operating and other purposes after universal metering is begun. But in view of all the foregoing considerations it is important that, during the first few years of the transition period, meter rates do not result in too great a reduction in revenue.

In discussing the extension of meter rates and their effect upon revenue and consumers' bills, it may be assumed that sufficient revenue to make the water works self-sustaining must be derived from the sale of water. Water revenue should be limited, however, to the amount required for that purpose, and meter rates should not be adjusted with a view to creating a surplus that can be used for other corporate purposes. Attention has already been called in this report to the tendency within the past two or three years to increase very largely appropriations diverting the water fund to general corporate purposes in no way connected with the water works.

The Cleveland meter rate is 5⅓ cents per thousand gallons, (subject to certain minimum charges heretofore referred to) the city owning and maintaining the meters. The Milwaukee rate is 6 cents per thousand gallons with no minimum charge, the consumer paying at that rate for whatever water he may take and no more. In Milwaukee, however, each consumer installs and maintains his meter at his own expense.

The Chicago meter rate now in effect is 62½ cents per thousand cubic feet, subject to a discount of 25 per cent for prompt payment. This is equivalent to approximately 6¼ cents net per thousand gallons. There is no minimum charge. Chicago premises now under meter con-

trol, except those in the third group mentioned below, are supplied such large quantities of water that a minimum charge if applied to them would have no practical value. Metered premises are of three general classes, namely: (1) those used for certain industrial and commercial purposes; (2) those on which the annual flat rate charge would aggregate $100 or more*—usually large apartment buildings; and (3) private residences and small apartment buildings—principally those situated in sections of the City where meters were installed prior to annexation.

Flat rate charges range from $1.88 to $30 net per year.* Prior to June 25, 1917, they applied to 93 per cent of all premises, and produced approximately half the revenue derived from the sale of water. The premises to which these charges are applicable include substantially all residences and small apartment buildings; also many larger apartment buildings and many buildings used for commercial purposes.

What would be the effect upon water revenues if the present rate of 6¼ cents per thousand gallons, with no minimum charge, were retained and all unmetered premises were immediately placed under meter control? No reliable estimate can be made, but in a general way, it may be said that probably there would be some loss of revenue due to reductions in the bills of thousands of small consumers. No definite data upon which to base such an estimate exist. Not even a complete classification of the unmetered premises, according either to their size or the nature of their occupancy, or to the charges paid, is available.

With respect to the larger users of water who are now supplied on the flat rate basis, such information as has been compiled tends to the conclusion that the charges

*See pages 66, 172.

against many of them would not be materially affected by a change to the meter basis; a considerable number of others would profit by the change; others would have their bills increased. The revenue in the aggregate would probably be increased somewhat; at least there is no occasion for anticipating any decrease in the total revenue received from this class of consumers.

So far as those smaller consumers who are careful about waste and leakage are concerned, a change to the meter basis would mean that they would pay much less than they now pay. Many of them would pay ridiculously small sums for the service furnished them. Hence, metering the small consumers would undoubtedly mean a considerable loss of revenue. To what extent this loss would be offset by the increase in revenue from the larger users can only be conjectured in the absence of more definite information than is now at hand.

Minimum Charges

Partly to guard against too great a loss of revenue from this last source, minimum rates should be fixed. That is, owners or consumers should be required to pay for a certain amount of water whether or not they use it. For all water used in excess of the quantity which the minimum charge will purchase, they will then pay at the usual rate.

Another justification for a minimum charge is that it tends to apportion to each consumer the actual cost of supplying him with service.

In establishing minimum charges two other considerations should also be kept in mind. Such charges should be lower than the present flat or frontage rates—substantially lower, so that the ordinary householder can, if he is careful to avoid waste and leakage, save money

without in any way using less water than he is ordinarily accustomed to use. Again, they should be high enough to encourage the use of all the water which health and comfort require; high enough to deprive either the owner, who pays his own water bills, or the landlord, who pays the bills for his tenants, of any incentive to stint either himself or his tenants; and high enough so that every person will feel that he may as well use all the water he needs, since it must be paid for whether actually used or not. At the same time, minimum charges should not be so high as to entitle consumers to substantially more water than they can use to advantage, and thus to make them careless about waste and leakage.

The determination of a plan upon which to base minimum charges presents a problem in itself. The Superintendent of Water, Mr. W. J. McCourt, the Assistant City Engineer, Mr. H. S. Baker, and the General Foreman of Meter Shops, Mr. F. D. Anderson, in a report dated October 22, 1913, recommended that "an annual minimum charge, on all meter controlled premises..... shall be made by deducting from the assessed [frontage or flat] rates the per centum of *estimated* annual excess revenue [from both meter and assessed rates accounts] over the *estimated* annual expenses appropriated for the current year."

This plan is open to several objections. Under it the careful consumer might or might not save money; much would depend upon the estimate of revenue, the appropriations made by the City Council and the resultant excess of revenue, if any. A probable excess of revenue over the amount required for necessary expenses would be a constant temptation to extravagant and wasteful appropriations. If the resultant minimum charges were high and would entitle consumers to more water than they

could legitimately use, it would tend to make users careless about waste and leakage, since they would save nothing by being careful. It is predicated upon the continuance of the present assessment system and the expense involved therein.

The report of the Committee of the City Club of Chicago on Water Waste—Messrs. Edward W. Bemis, Ray Palmer, and Henry W. Claussen—dated June 9, 1915, suggests a sliding scale of minimums based upon present frontage rates. It tentatively proposes, for instance, that "those now paying on the flat or frontage rate $7.00 or less, might pay a minimum of $4.00" and that "those paying a frontage rate of over $7.00 and under $10.00, might be asked to pay a minimum of $6.00 per year, and other classes of consumers might be correspondingly treated."

This plan would make it possible for careful consumers to save money and would encourage them to avoid waste. At the same time the minimum rates mentioned would provide all the water that many consumers could make any legitimate use of. One objection is that this plan involves the expense of administering the assessment system.

From the administrative standpoint, it will be much simpler and less expensive if the minimums are fixed on the basis of the number of apartments, flats, or occupancies supplied by each meter. For instance, a minimum charge of $4.00 might be made for a private residence or other single occupancy, with a further charge of $3.00 for each additional apartment, flat, or occupancy.

As a practical matter, experience will probably demonstrate that it will be necessary to apply the minimums fixed under either of the first two plans above referred to principally in the case of small residences and flat or

apartment building premises. The larger consumers, as Mr. McCourt and his associates in their report say, "will never be really involved from a minimum charge standpoint, because they consume too much water to fix any proper basis to establish arbitrary or flat charges from the point of service rendered, and, therefore, their consumption must be charged for under meter measurement, which will cause bills that will always exceed bills under any minimum charge produced out of our present assessed rates."

In view of this situation, it would seem unnecessary to consider for larger premises an elaborate schedule of minimum charges based upon the various existing flat rates. It would also seem that minimums may well be fixed with a view to their covering principally those smaller premises to which alone such charges will in most cases be found to have any application.

The amounts mentioned in the last plan above suggested are of course tentative. In support of them it may be said, however, that they are low enough to make it possible for the owners of most small residences and small flat buildings to save money on their present water bills. At the same time they will purchase all the water used on a large proportion of such premises. The average annual meter charge for residences in Austin was found to be about $4.50; and for residences in Morgan Park, $4.00. At 6¼ cents per thousand gallons, $4.00 will purchase the average yearly residential consumption in Oak Park. Also, it will buy more water than half the consumers in Cleveland use. Five dollars and seventy cents was found to be an average two-flat building charge in Austin, and $7.00 will buy more water than three-fourths the Cleveland consumers use. Lastly, the amounts proposed will protect the water fund against

loss from those extremely small users who otherwise would pay entirely too little for the service furnished them.

The question of the ultimate adjustment of meter charges is an important one, and the Bureau recognizes that it should be given careful consideration. It is not at all probable, however, that rates fixed in the light of present information and existing conditions will stand permanently. For instance, if the policy of universal metering is undertaken, by the time meters have been installed on all premises and perhaps even before that time, a substantial reduction in present rates applicable to large and small consumers alike should be possible. Experience will determine the need for future adjustments —adjustments which can properly be made only in the light of experience. To attempt, before universal metering is started, to anticipate refinements and adjustments such as may be found expedient in the future is likely not only to prove futile but to delay the adoption of the metering program.

The Bureau believes, therefore, that universal metering should be undertaken at once; that the meter rate of $6\frac{1}{4}$ cents per thousand gallons now in effect should be retained for the present; that minimum rates should be established upon the basis of the number of occupancies served by each meter, or upon some modification of that idea which is simple to administer and may be easily understood by the average consumer, and which will produce those generally desirable results which are the proper end of minimum charges. The Bureau believes further that if such a program is put into effect immediately it will result advantageously to thousands of small property owners, and that it will not materially impair the water revenue.

What Metering Will Effect:

Waste Reduction—Improved Service—Money Saving

Universal metering supplemented by the repair and rehabilitation of the distribution system will stop within a comparatively short time such waste and leakage as it is practicable to prevent, and will make it possible thereafter to control them permanently. That is the experience of other cities where metering has been tried, and the same results will follow in Chicago as elsewhere.

Cleveland inaugurated the policy of universal metering in 1902. The plant had then been in operation 46 years, and the per capita consumption had reached 169 gallons per day. Six per cent of the premises were metered at that date. By the close of 1909, this percentage had been increased to 97, and waste and leakage had been so far eliminated that the per capita consumption had been reduced to 97.8 gallons per day. Since 1909 the per capita consumption has increased to 113.2 gallons per day in 1916. The increase of the last few years is to be accounted for in part by a larger industrial use and in part by the growing tendency in Cleveland as in other American cities to use more water for domestic purposes, due to the requirements of better standards of living and the more widespread installation of facilities for using water.

Boston began extending the meter system in 1909. In 1908, 5.7 per cent of the services were metered, and the per capita consumption was 153 gallons per day. By the close of 1916, 66 per cent of the services had been metered, and the per capita consumption had fallen to 105 gallons per day. Boston also supplements metering to some extent by house-to-house inspections.

Milwaukee began to install meters on an extensive scale relatively soon after the plant was built. During 1887 the

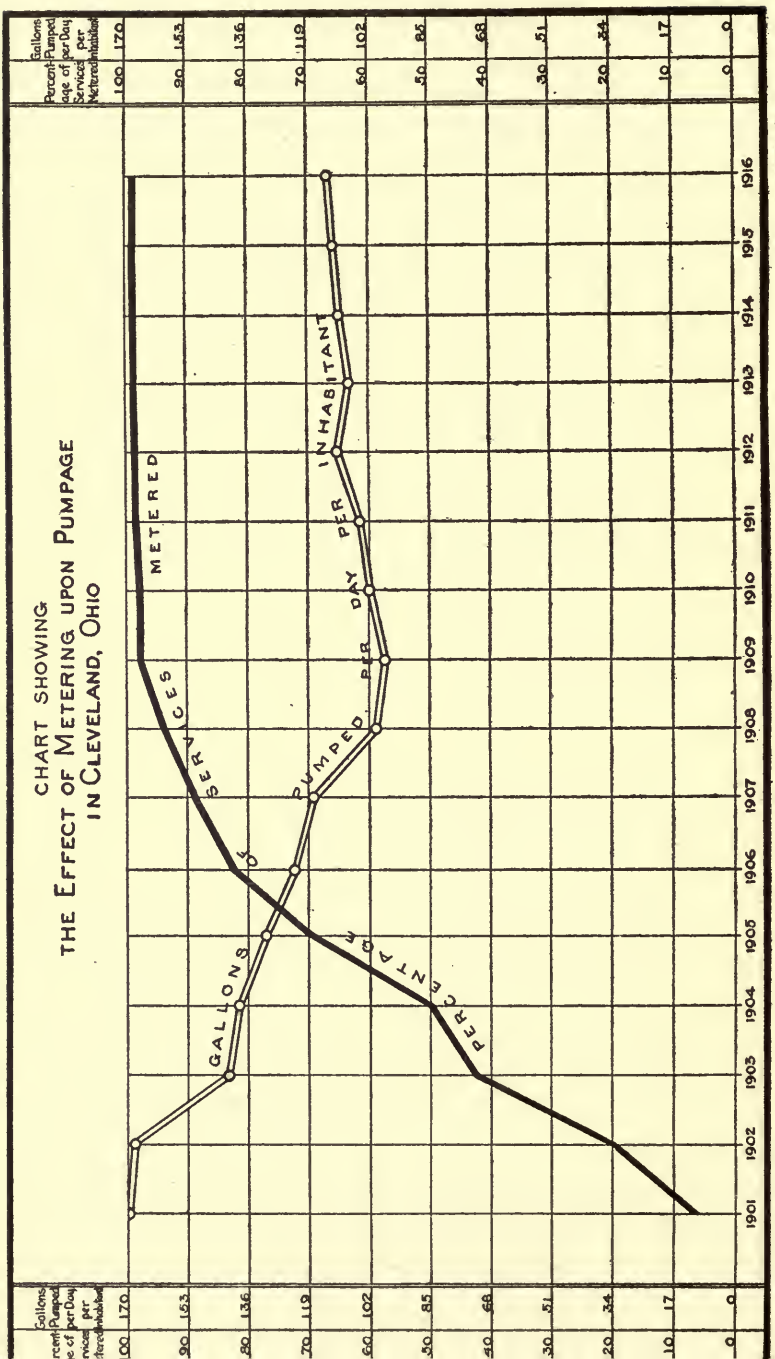


CHART SHOWING
THE EFFECT OF METERING UPON PUMPAGE
IN CLEVELAND, OHIO
GALLONS PUMPED PER DAY PER INHABITANT
PERCENTAGE OF SERVICES METERED
Percentage of Services Metered
Gallons Pumped per Day per Inhabitant
100 90 80 70 60 50 40 30 20 10 0
170 153 136 119 102 85 68 51 34 17 0
1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

per capita consumption reached 113 gallons per day. The total pumpage then approached the capacity of the plant and measures to conserve the supply were immediately necessary. Metering was decided upon and was gradually introduced. During the fifteen-year period ended in 1902, the daily per capita consumption was reduced from 113 gallons to 80 gallons. Since 1902 the per capita consumption has steadily increased, until in 1916 it reached 118 gallons per day, although at the close of last year the percentage of services metered had been increased to 99. This is explained by the fact that Milwaukee began to introduce universal metering before facilities for the use of water for domestic purposes were furnished extensively, and before its industrial consumption had been fully developed. Subsequent development along both these lines accounts for the increased consumption of recent years which under the circumstances was to be expected. There is no doubt, however, but that Milwaukee has profited greatly from undertaking to control waste and leakage early in the development of its water works system. Otherwise the losses from these sources probably would have reached as serious proportions as they have in Chicago.

Conditions in Chicago with respect to both domestic and industrial consumption are more nearly comparable with conditions in Cleveland and Boston at the time metering was undertaken in those cities. The general introduction of meters in Chicago may therefore be expected to produce results similar to those secured by Cleveland and Boston. The Bureau believes that it is practicable through metering and proper attention to checking leaks in the distribution system to reduce waste and leakage in Chicago so that the per capita consumption, which in 1916 was 259 gallons per day, will not

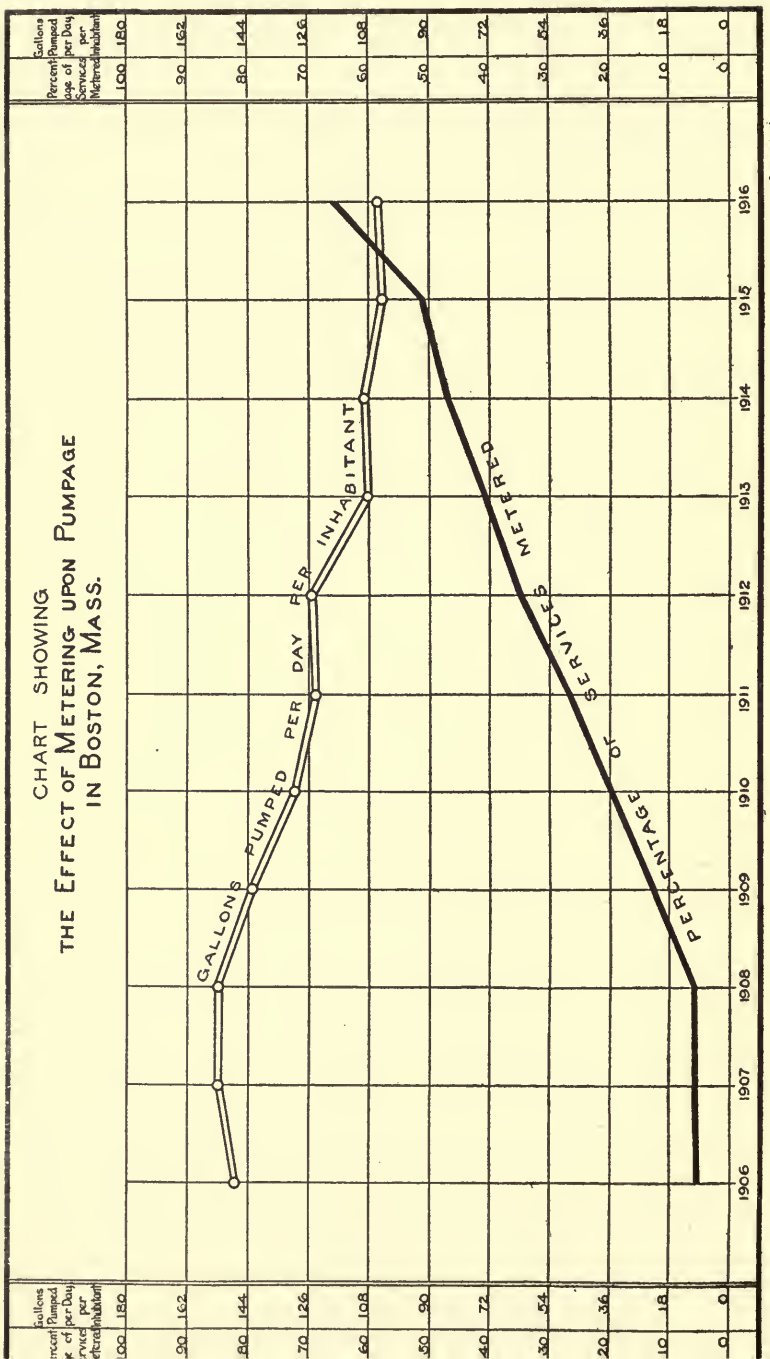


CHART SHOWING
THE EFFECT OF METERING UPON PUMPAGE
IN BOSTON, MASS.
GALLONS PUMPED PER DAY PER INHABITANT
PERCENTAGE OF SERVICES METERED
Gallons Pumped per Day per Inhabitant
Percent of Services Metered
1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916
0 18 36 54 72 90 108 126 144 162 180
0 10 20 30 40 50 60 70 80 90 100
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

exceed 125 gallons per day. As has already been indicated, that amount of water will provide an abundant supply for all purposes.

The benefits which will accrue from this reduction in waste and leakage will be twofold in nature. The service will be greatly improved and a very large money saving will be effected.

The improved service which will result will be the important primary benefit. It will mean that consumers in all sections of the City, including those situated at points remote from pumping stations and those occupying the upper floors of buildings, will have an uninterrupted supply of water, delivered at all hours under pressure that will enable them to draw water promptly and in abundance. Such a condition has never existed in Chicago.

The relation of waste and leakage to the present inadequacy of supply and insufficiency of pressures has been previously discussed. It is sufficient at this time to repeat that waste reduction will result in materially raising pressures throughout the distribution mains, without necessitating any increase of pressures at the pumping stations. Reducing the amount of water transported will reduce velocities in the mains and therefore the losses of pressure due to friction caused by the flowing water. Such losses which now often amount to from 10 to 15 pounds can be reduced to less than five pounds, and the pressures at which water will be delivered to consumers without any additional cost for pumping will be increased accordingly. Also with waste and leakage reduced to a reasonable minimum, the pumps can raise the pressures at present maintained at the pumping stations, if it is necessary or desirable to do so, thus increasing still further the pressures at which the water

will be delivered. Under present conditions this cannot be done during periods of greatest consumption, and to attempt it at other times would result in additional expense for pumping, but in little improvement in service. Under the higher initial pressures the water would run away much faster through the thousands of wide-open leaks. The result would be more water pumped, higher velocities, greatly increased losses of pressure through friction, and little, if any, additional pressure at the points of delivery to consumers.

How Money Saving Will be Effected

There can be no doubt but that metering will be profitable as a business proposition, and since the water works is in effect a co-operative enterprise the profits which will accrue will be reflected in lower water rates. That meters will more than pay for themselves through the savings which they will make possible in other directions is certain. The only question is as to the extent of the aggregate saving. This saving will be effected in two ways: (1) by reducing expenditures for additions to the water works plant and (2) by reducing operating and maintenance costs.

Chicago can continue its present policy as to waste control or it can adopt universal metering as a means of preventing waste and leakage. The direct value of meters can be calculated by estimating the comparative cost of building and operating the water works plant under these alternatives. The following conclusions as to the financial benefits which will result from the general introduction of meters are based upon such an estimate made for the Bureau by Mr. John W. Alvord.

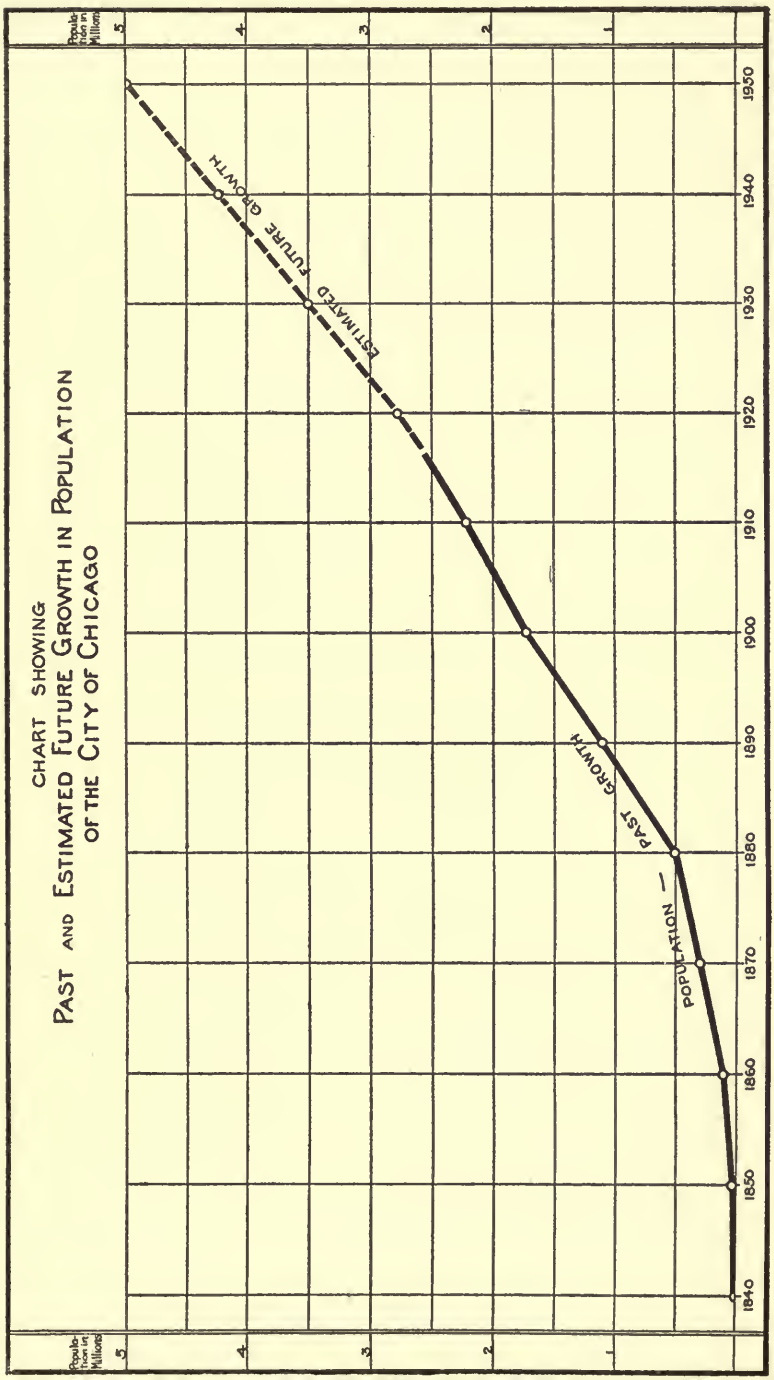


CHART SHOWING
PAST AND ESTIMATED FUTURE GROWTH IN POPULATION
OF THE CITY OF CHICAGO
Population in Millions
.5
1
2
3
4
5
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
POPULATION
PAST GROWTH
ESTIMATED FUTURE GROWTH
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

Savings in Capital Outlays for New Plant

The savings which can be effected by reducing capital outlays for new plant will depend upon the extent to which the construction of additional tunnels, cribs, pumping stations, and mains can be deferred or curtailed. The Chicago Water Works is far overbuilt for present needs. With the completion of the new Mayfair pumping station, which is expected early in 1918, the plant will have sufficient capacity to supply the legitimate requirements of a population of at least five million.* It is not probable that this population will be reached before 1950.** The obvious conclusion is that if waste and leakage are brought under control *it will not be necessary to construct any more tunnels, cribs, and pumping stations until after 1950.* The estimates of the Bureau are limited to the intervening period, although the savings which will result from the immediate installation of meters will ultimately aggregate much larger amounts than those set forth in this report.

Assuming that waste control in Chicago will continue

*Upon the completion of the Mayfair station and certain changes now in progress in the Chicago Avenue and Twenty-second Street stations, the plant will have a rated capacity of 1,100 million gallons per day. Assuming an average daily per capita consumption of 125 gallons, this is sufficient capacity to supply a population of five million and to provide an ample reserve for peak load periods and other purposes.

**The estimated population of Chicago in 1916, upon the basis of the Federal census, was 2,491,933; upon the basis of the school census of March, 1916, it was 2,550,000. It is the concensus of opinion among persons who have made a study of the probable future growth of the city that the population will reach five million about 1950. In discussing this subject the Chicago Traction and Subway Commissioners (Messrs. Wm. Barclay Parsons, Bion J. Arnold, and Robert Ridgway) in their recent report said:

"A study of these [population] charts and a careful analysis of the various economic conditions in the city, as disclosed by recent investigations of other boards and commissions and by studies made by the Commissioners, point to the general conclusion that it is reasonably safe to assume that Chicago's growth will continue at a rate which will realize a population of not less than 5,000,000 persons by about the year 1950. In a number of exhaustive studies of this population question for Chicago the prediction is made of a population ranging from 4,500,000 to 5,500,000 by 1950."

MAP OF THE

CITY OF CHICAGO

Showing

Distribution of Population

Based on School Census of March 1915

POPULATION — 1 Dot to 250

Each Dot Represents 500 People

to be what it has been up to the present time, Mr. Alvord assumes also that the per capita consumption will continue to increase in the future as in the past, and estimates that by 1950 it will reach 415 gallons per day; also that the pumpage at that time will be 2,000,000,000 gallons per day. Mr. Alvord assumes further that the construction of tunnels, cribs, pumping equipment, and distribution system will necessarily be made to keep pace with the growth in total consumption, and estimates that the total cost of the water works plant which at the close of 1916 was $70,773,556 will reach the sum of $200,000,000 by 1950.

Assuming, on the other hand, that a policy of universal metering is adopted; that beginning with 1918 all new services will be metered as connected to the mains; that all old services will be metered within the next ten years at a uniform rate of ten per cent per year; and that a comprehensive waste survey, which will reduce waste and leakage outside the property lines of consumers to 23 gallons per day, will be carried on at the same time, it is Mr. Alvord's belief that the per capita consumption can be reduced to 125 gallons per day by 1928, and that the pumpage can be reduced to 425,000,000 gallons per day at that time as compared with 645,000,000 gallons per day in 1916; also that the daily pumpage can be kept considerably below this 1916 figure as late as 1950.

This reduction in pumpage will make possible an immense saving in expenditures for water works plant. It will mean that *additional tunnels, cribs, and pumping stations will not be needed for 33 years* and that during that time there will be no necessity for laying new feeder mains except in localities which are at present undeveloped.

Mr. Alvord estimates the cost of the plant which will

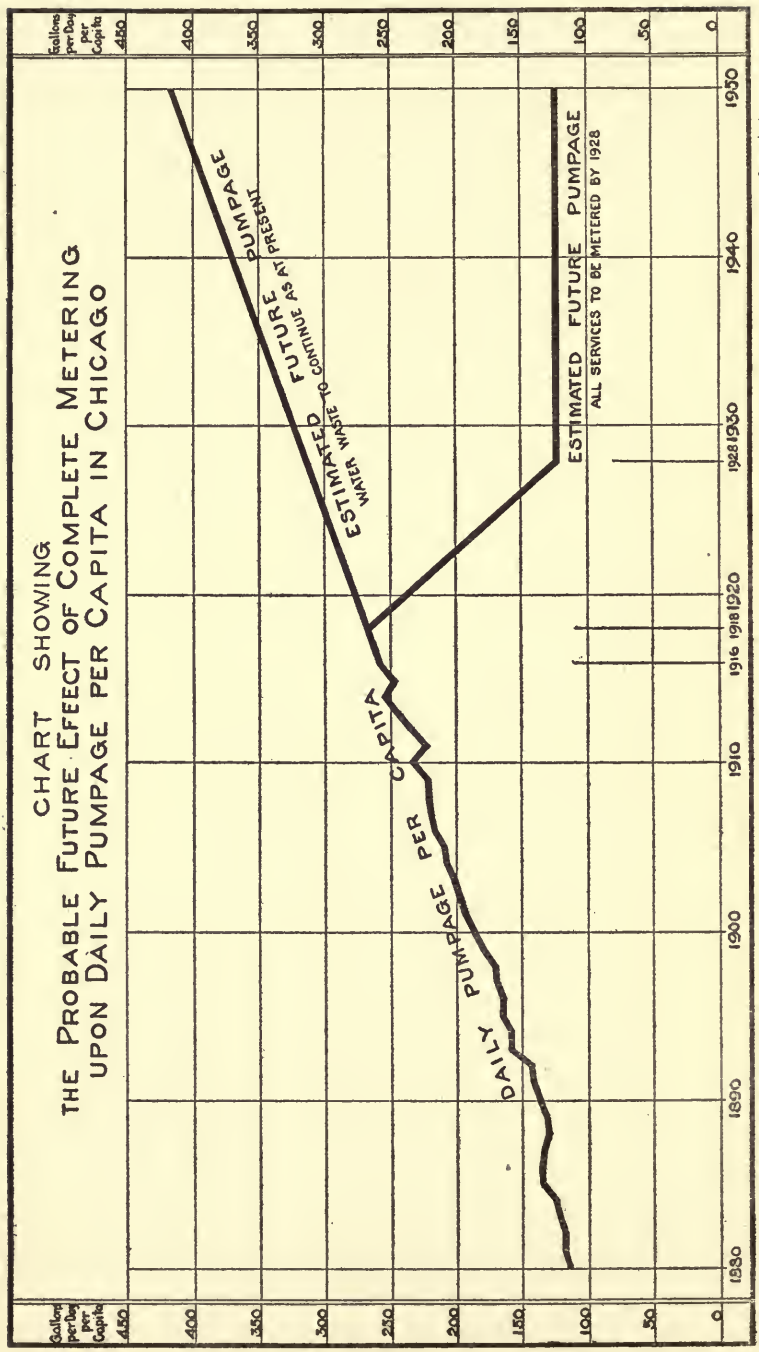


CHART SHOWING
THE PROBABLE FUTURE EFFECT OF COMPLETE METERING
UPON DAILY PUMPAGE PER CAPITA IN CHICAGO
Gallons per Day per Capita
450
400
350
300
250
200
150
100
50
0
1880
1890
1900
1910
1916
1918
1920
1928
1930
1940
1950
DAILY PUMPAGE PER CAPITA
ESTIMATED FUTURE PUMPAGE
WATER WASTE TO CONTINUE AS AT PRESENT
ESTIMATED FUTURE PUMPAGE
ALL SERVICES TO BE METERED BY 1928
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

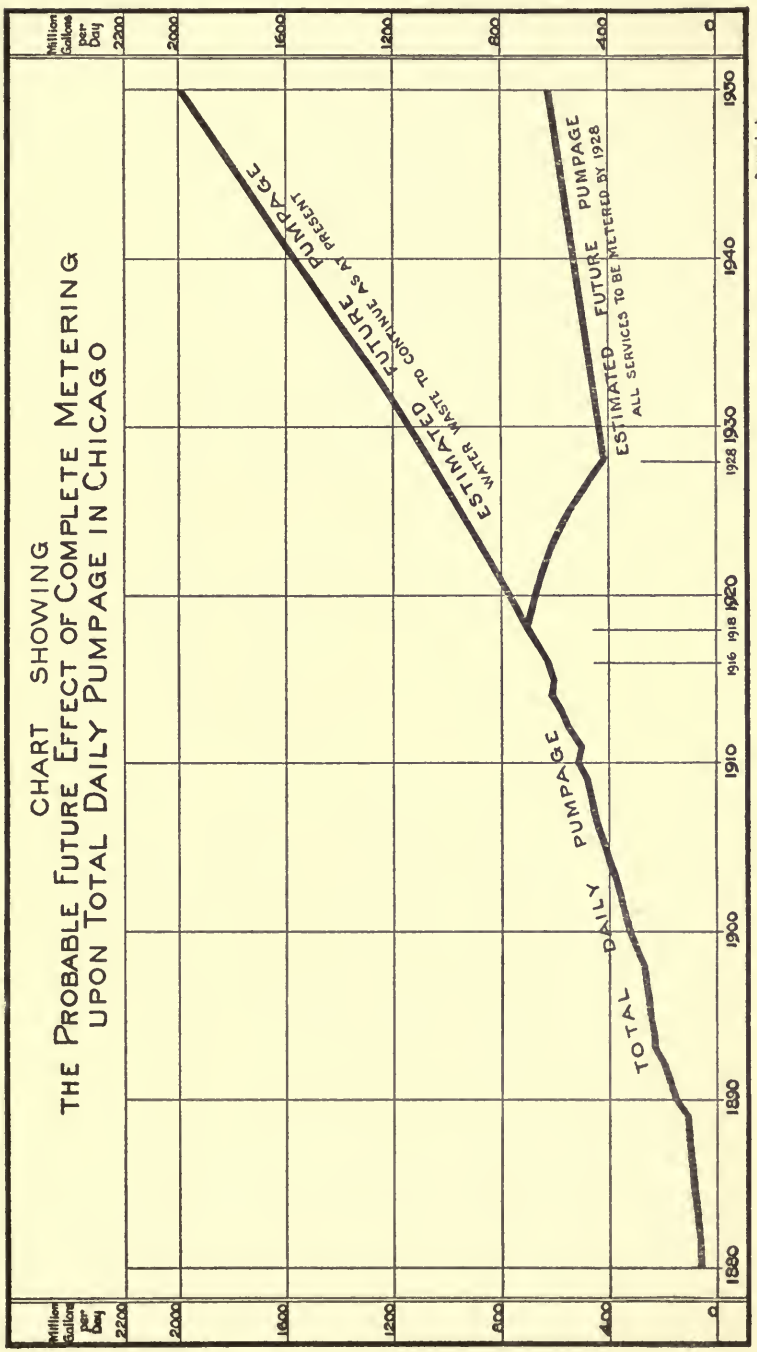


CHART SHOWING
THE PROBABLE FUTURE EFFECT OF COMPLETE METERING
UPON TOTAL DAILY PUMPAGE IN CHICAGO
Million Gallons per Day
2200
2000
1600
1200
800
400
0
1880
1890
1900
1910
1916
1918
1920
1928
1930
1940
1950
TOTAL DAILY PUMPAGE
ESTIMATED FUTURE PUMPAGE
ALL SERVICES TO BE METERED BY 1928
ESTIMATED FUTURE PUMPAGE WASTE WATER TO CONTINUE AS AT PRESENT
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

be required prior to 1950 under these conditions at $106,000,000. In making this estimate it is assumed that the construction of pipe lines 14 inches and under will continue at the same rate as at present, but that the construction of large feeder mains, except as required to develop new territory, will not be required previous to 1950. The cost of meters and their setting, estimated at $24.00 per meter, is included in the cost of the plant under this plan. On this basis the aggregate cost of installing meters during the first 10 years will be approximately $9,000,000, or an average of $900,000 per year. After all services are metered, the annual cost of meter installations necessitated by the increase in population will be approximately $200,000.

The difference in the cost of the plant under the different conditions above outlined represents the additional investment which will have to be made unless universal metering is adopted and is supplemented by waste surveys to check leakage in the distribution system. Assuming present conditions to continue until 1950, this additional investment will reach $94,000,000. The money thus invested (as well as the money to operate and maintain the plant in which it is invested) will have to be advanced by water consumers in addition to the moneys which otherwise will be required of them.

The immediate loss (exclusive of increased operating charges) entailed by this additional investment will be the value of the use of the fund invested plus the loss due to depreciation on the equipment. Assuming an annual interest rate of 4 per cent (which is the prevailing rate on municipal loans) and an average annual depreciation charge of 1 per cent (which is a usual charge on water works properties), during the period between now and

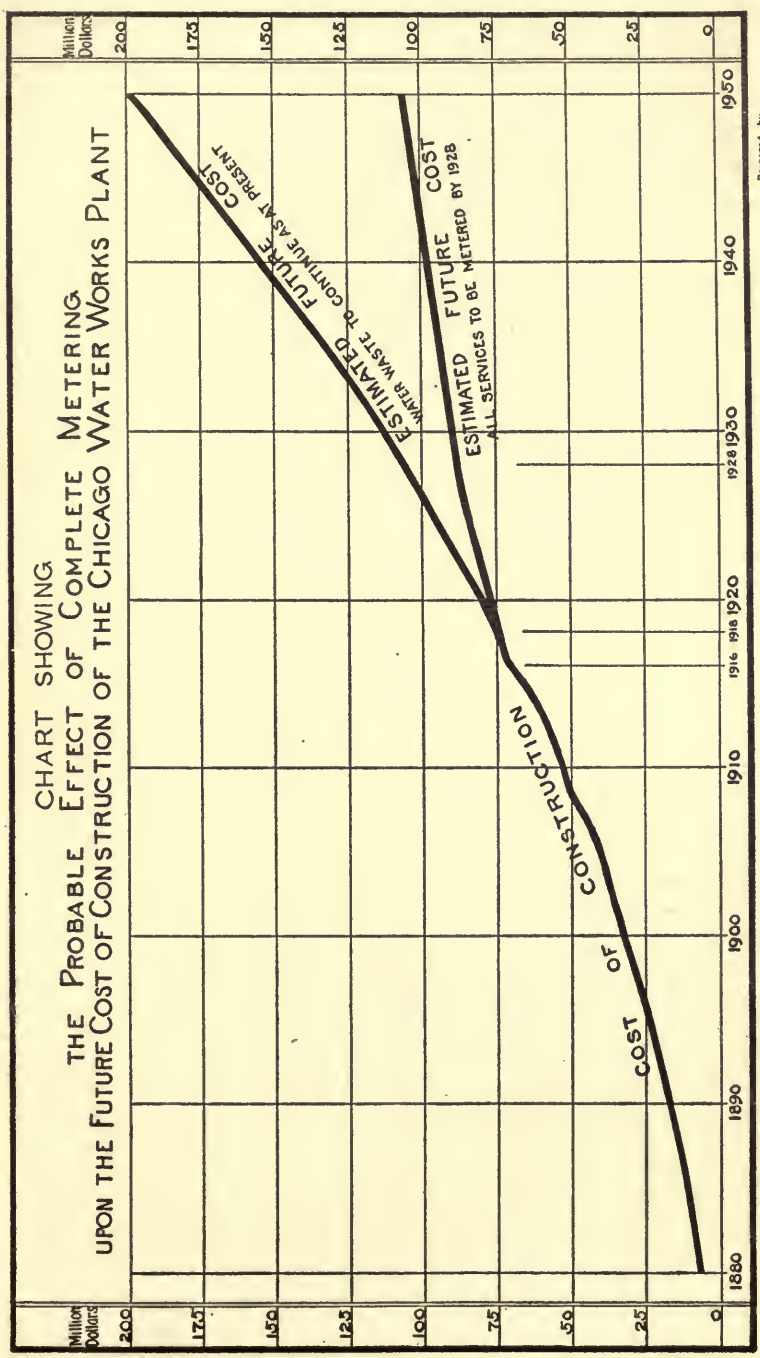


CHART SHOWING
THE PROBABLE EFFECT OF COMPLETE METERING
UPON THE FUTURE COST OF CONSTRUCTION OF THE CHICAGO WATER WORKS PLANT
Million Dollars
200
175
150
125
100
75
50
25
0
1880
1890
1900
1910
1916
1918
1920
1928
1930
1940
1950
COST OF CONSTRUCTION
ESTIMATED FUTURE COST
ALL SERVICES TO BE METERED BY 1928
ESTIMATED FUTURE COST
WATER WASTE TO CONTINUE AS AT PRESENT
Prepared by
CHICAGO BUREAU OF PUBLIC EFFICIENCY
1917

1950 the losses from these items will aggregate $53,000,000 and $13,000,000, respectively. These sums, therefore, represent the immediate savings which can be effected by reducing expenditures for additional plant. The table on page 206 shows the estimated savings for shorter periods.

The ultimate loss on the additional investment, and therefore the ultimate saving involved in avoiding the necessity for such investment, will depend upon what use, if any, can be made of the additional physical plant in existence at the end of any period that may be selected as the basis for an estimate. Assuming a further continuation of the present policy, interest and depreciation charges will run on indefinitely. Assuming, on the other hand, that at some future date this policy will be abandoned and effective waste control measures put into effect, the loss incurred subsequent to that date will depend upon the extent, if any, to which the remaining plant investment not then required for immediate use can thereafter be utilized.* The availability of such plant for future use will be determined largely by the future growth of population within the territory which it is constructed to serve. Upon such parts of the equipment as are in fact subsequently used the loss will be measured by the interest and depreciation charges while such use is deferred. Since, however, the use, if any, of such equipment will not be immediate and may be long deferred, depreciation may operate to impair its value so seriously as to amount to the practical destruction of the investment. As to those parts for which no future use is found, the investment will of course be entirely lost. This ultimate loss will depend, therefore, upon a multiplicity of

*It is assumed that, so far as the original investment has become impaired through the use of the plant or otherwise, the loss prior to such date is included in the item of depreciation.

various conditions—the amount of capital actually invested in the plant; whether or not equipment not required immediately can be used subsequently; and how long such use, if any, will be deferred. To attempt to anticipate these conditions and to estimate such loss, or, stated conversely, the saving which will result from avoiding it, would be futile. The Bureau wishes to call attention, however, to the fact that the savings which it has estimated are not the only savings involved in reducing expenditures for additional water works plant. To the extent that the investment in such plant can be avoided the City will save itself additional losses which otherwise will result. Of course there are also other distinct advantages to be gained by not investing capital in equipment until its use is actually required.

Savings in Operating and Maintenance Costs

The savings which can be effected in operating and maintenance costs will result largely from the reduced pumpage which will be required with preventable waste and leakage eliminated. A reduced pumpage will mean reduced expenditures for labor, fuel, supplies, repairs, and other purposes.

Mr. Alvord estimates that, if the present policy as to waste control is continued, operating and maintenance costs which in 1916 amounted to $3,530,000 will increase to $10,054,000 by 1950, and that the average annual cost of operation for the 33 years beginning with 1918 will be $6,880,000. This estimate is based upon a study of operating conditions and costs for the past ten years as reported by the annual reports of the Department of Public Works and upon the assumption that the pumpage will increase as heretofore indicated.

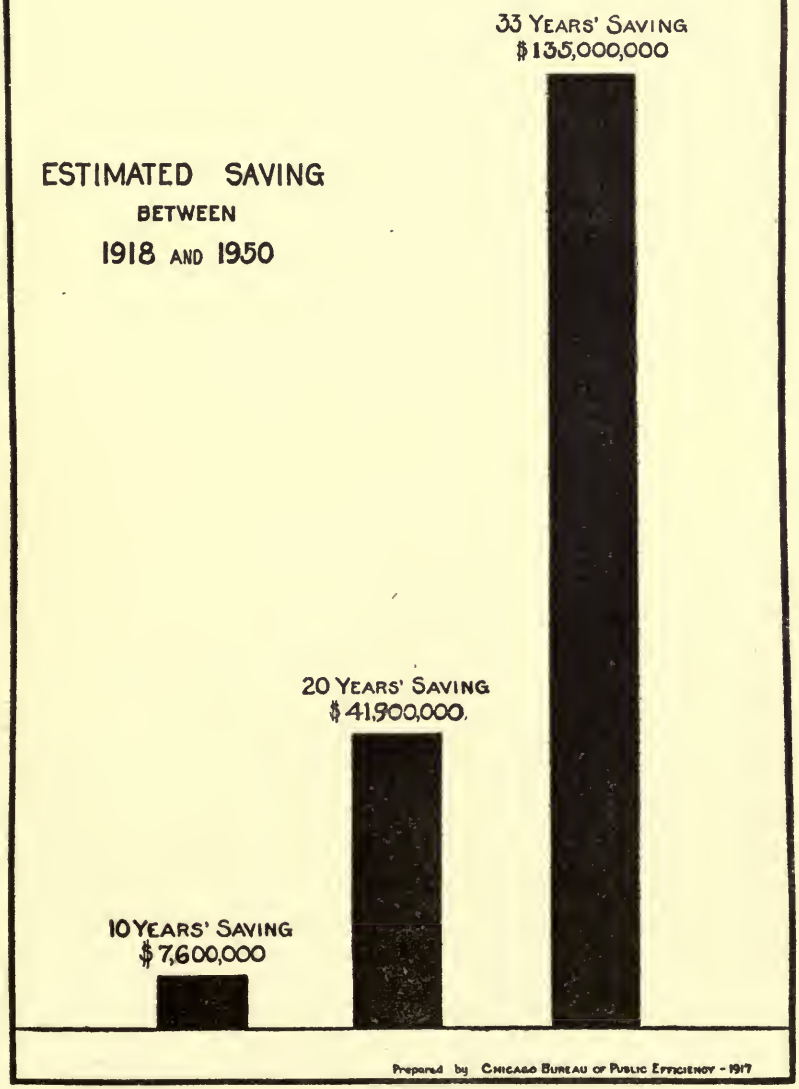
Mr. Alvord also estimates that, with the reduced pump-

age that will result from the program for waste control outlined on page 197, operating and maintenance costs will increase to only $5,640,000 by 1950, and that the average annual cost will be $4,780,000. This estimate includes an amount to cover the cost of a comprehensive waste survey and to provide for repairs, maintenance, reading and accounting on the meters. The annual cost of repairing and reading meters is estimated at $1.50 per meter and will average approximately $290,000 per year for the first 10 years. With the system completely metered at the end of the tenth year, the cost of these items will be approximately $575,000 per year, and thereafter, as the number of meters increases, will increase at the rate of about $12,500 per year. Under this plan the total saving in operating costs which will be realized during the next 33 years will amount to $69,000,000.

Total Saving to be Effected

The estimated savings in interest and depreciation on the water works plant and in operation and maintenance costs which will result from universal metering will thus aggregate $135,000,000 during the 33-year period ending 1950. The following table shows also the estimated savings which can be effected for periods of 10 and 20 years. It will be noted that in the first ten years not only will universal metering save $7,600,000 but that under it the estimated amount of capital necessary for investment in plant will be $15,000,000 less than will be required if present conditions of waste continue. This difference of $15,000,000 in capital outlay is net, allowance having been made for the entire cost of installing the meters.

CHART SHOWING
THE ENORMOUS SAVING THAT CAN BE MADE,
WITHOUT RESTRICTING THE USE OF WATER,
IF UNIVERSAL METERING IS ADOPTED AS A MEANS OF
PREVENTING WATER WASTE AND LEAKAGE



Prepared by CHICAGO BUREAU OF PUBLIC EFFICIENCY - 1917

Table Showing Estimated Additional Capital Which Will Be Required to Construct Water Works Plant If Universal Metering Is Not Adopted; also Estimated Saving Which Can Be Effected by Universal Metering During Different Periods Beginning in 1918

	10 Years	20 Years	33 Years
Additional Capital to be Required in Absence of Universal Metering.....	$14,950,000	$46,850,000	$94,000,000
Saving to be Effected by Universal Metering—			
Interest at 4%.....	$2,830,000	$15,390,000	$53,000,000
Depreciation at 1%.....	710,000	3,850,000	13,000,000
Ordinary Operating and Maintenance Charges.....	4,060,000	22,660,000	69,000,000
Total Saving to be Effected by Universal Metering During Respective Periods.*	**$7,600,000**	**$41,900,000**	**$135,000,000**

*No attempt has been made to estimate the further saving to be effected by avoiding the loss which will result after the expiration of the respective periods from the destruction or deferred use of the additional capital which will have to be invested if universal metering is not adopted. (See pages 202-3.)

RESPONSIBILITY FOR EXISTING CONDITIONS

The City Engineer and other administrative officials for more than fifteen years have been urging the City Council to authorize metering as the only means by which permanent relief from waste and leakage, and the resultant inefficient service and financial loss, can be obtained. The Mayor and the Aldermen, however, have thus far failed to support these appeals in anything like an adequate way.

The public also is quite generally either apathetic or antagonistic to the idea of metering. This is because the public, for the most part, is not acquainted with the facts concerning the effect of meters both upon the use of water and upon water bills. Experience shows that a

meter will neither increase the water bill of the ordinary householder nor restrict him in his customary use of water, and that meters produce results entirely by eliminating waste and leakage, thus obviating the necessity for providing equipment with which to pump and distribute an enormous volume of water that serves no useful purpose.

The City Council should recognize this state of affairs and should accept the responsibility for remedying the existing situation by initiating and carrying out a program for universal metering. In this undertaking, the Council should have the earnest and active support of every householder, tenant, and property owner in the City.

3 0112 070311441